COMPLIMENTARY

EXPERIMENTAL HUSBANDRY FARMS

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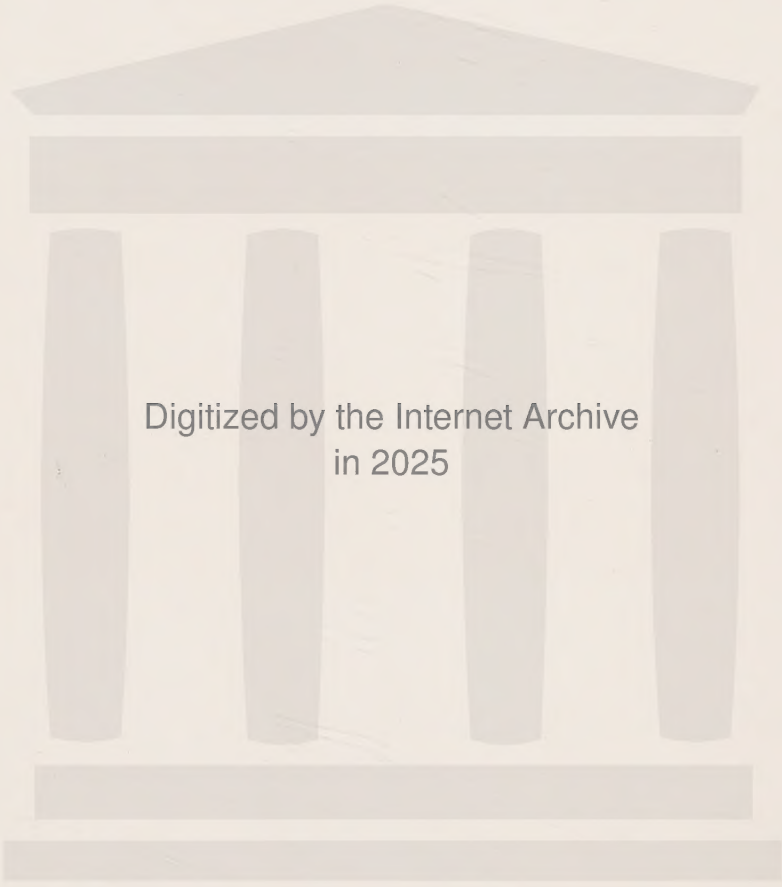
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MINISTRY OF
AGRICULTURE, FISHERIES AND FOOD

NATIONAL AGRICULTURAL ADVISORY SERVICE

Experimental Husbandry Farms and Experimental Horticulture Stations

FIFTH PROGRESS REPORT

LONDON
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Introduction

This is the fifth Progress Report on experimental work at the N.A.A.S. Experimental Husbandry Farms and Horticulture Stations.

The Report does not attempt to review the whole field of investigations in progress in any one year but presents a selection of topics of particular interest either because they are new to the experimental programme or because they have reached a stage where conclusions of practical importance can be reported.

For a fuller account of experiments being undertaken, other publications are available. Each centre prepares an Annual Report written mainly for the farmer and horticulturist, which can be obtained from the Director concerned (address on pp. 69–71). In addition, at the conclusion of most experiments the results are reported in *Experimental Husbandry*, *Experimental Horticulture* or other scientific or technical journals.

Results from Recent Experiments

CROPPING, MANAGEMENT AND SOIL ORGANIC MATTER

P. N. Harvey, *Gleadthorpe Experimental Husbandry Farm*

The organic matter present in soil influences the supply of plant food, water and air to the crop. It is necessary to distinguish between the value of organic matter as a source of plant food and its role in improving the structure of the soil and hence its water holding capacity and aeration. The effect on the supply of plant nutrients depends on the nature of the organic material; where crop and plant residues such as turf are incorporated in the soil, the total supply of nutrients is not increased (unless a legume is grown) since only nutrients originally taken up from the soil to support plant growth are returned in this way. Many organic manures, however, can increase the total supply of plant food when they contain extra nutrients derived from livestock feed imported from elsewhere. Some indication of the value of organic matter or organic manures can be deduced from analysis but, since only a proportion of the plant food which they contain is available to the crop in the year of application, their actual nutrient value may be considerably less than that indicated by their analysed composition. The value of organic manures can be best measured by a comparison of their effect on crop production with those of equivalent quantities of plant nutrients supplied in inorganic form. If a given amount of plant food contained in an organic manure produces better crops than a dressing of chemical fertilizer which supplies the same amount of plant food, the difference can be ascribed to factors such as improved water holding capacity or crumb structure, the effects of which cannot be measured directly.

The results of many experiments suggest that crops receiving organic manure as well as inorganic fertilizer, yield better than if they were only given the inorganic part of the dressing. However, in much of this work, the quantities of nutrients supplied by the inorganic fertilizer were less than the crop needed, so that the apparent benefit of the organic manure could be explained in terms of the extra plant food which it supplied. In more recent experiments, such as those at the Experimental Husbandry Farms and the Norfolk Agricultural Station concerned with the fertility of leys or the disposal of cereal straw, the effects of organic additions as FYM or straw have been tested in the presence of optimum inorganic fertilizer dressings. For example, in an all arable rotation, potatoes manured with 90–120 units N, 90 units P_2O_5 and 180 units K_2O per acre have, over 8 years, produced 1 ton/acre more tubers where 14 ton/acre FYM was also given: after three years of a grazed ley the benefit of the FYM was reduced by half. Again, at the Norfolk Agricultural Station, the average results for six years in an all arable rotation indicated a response of 1 ton/acre potatoes to a dressing of 11 ton FYM in the presence of 80 units N, 72 units P_2O_5 and 120 units K_2O per acre as inorganic fertilizer: during the same period the corresponding increase for sugar beet adequately supplied with inorganic plant nutrients was around ½ ton per acre.

This evidence suggests that the benefit from dung which was not due to the plant nutrients it contained has been relatively small since the needs of the crop

were adequately supplied by the inorganic part of the dressing. In many instances, however, the gain from FYM was greater in a dry year which points to some some improvement in water holding capacity. Other contributory factors are the improved aeration of the soil due to better crumb formation, possibly also because the plant food in organic matter is more gradually available to the plant and there is less wastage from leaching than is the case with large and infrequent applications of inorganic fertilizer.

Factors that Influence the Supply of Organic Matter to Soils

The organic matter in soils is subject to a continuous process of decay and consequently the amount present at any time depends on the balance between the accumulation of organic materials, such as plant residues or organic manures, and the wastage by oxidation and the action of soil organisms. On light soils which are open textured, well aerated and quick to warm up, organic matter decays more rapidly and losses tend to exceed replenishment so the organic matter content of these soils is generally low. On soils of heavier texture the rate of wastage is slower and, since stronger land normally grows bigger crops which leave more plant residues, the reserves of organic matter in clay or loam soils tend to be maintained at a higher level than in light land. At the other extreme there are badly drained soils where lack of aeration retards the decay of organic material which therefore accumulates to produce soils rich in organic matter such as fen or peat.

Management is the other main factor which influences the balance between accumulation and decay. When down to grass, the soil remains undisturbed and organic matter builds up particularly under grazing conditions. In arable cropping, normal cultivations tend to accelerate the processes of decay and prevent any accumulation of organic matter. In a system of ley farming where grass alternates with arable crops, the organic matter content is likely to vary between $2\frac{1}{2}$ and 3 per cent on light soils and 3 to 4 per cent on heavy soils: under continuous arable cultivation the figure rarely rises above 3 per cent and it may fall on light soils to 1 per cent. However these changes take place slowly and the rate of both accumulation and loss is very gradual. Anything over 4 per cent organic matter is high and on most soils it is difficult to raise it beyond that point: for example, at Rothamsted plots which have received an annual dressing of dung for 100 years now stand at 4 per cent compared with 2 per cent where the land received no inorganic fertilizer or organic manure throughout this long period. Clearly it takes a long time to run down organic matter levels and equally a long time to restore them again. But what constitutes a dangerously low level and how long can one farm successfully on a system which tends to dissipate organic matter rather than conserve it? Some light is shed on these questions by information obtained from the long term rotation experiments which have now been in progress at the Husbandry Farms for upwards of ten years.

Effect of Cropping and Management on Soil Organic Matter

Of these experiments the one concerned with measuring the fertility left by leys is perhaps giving the most useful information on this subject. The experiment has been carried out at six centres, ranging from blowing sand at Gleadthorpe,

to boulder clay at Boxworth, with two centres on chalk loams and two on silty clay loams derived from the old Red Sandstone and Silurian shales respectively. The cropping is based on a six course rotation in which three "treatment" phases, which may be either in grass or arable crops, are followed by three years of potatoes, wheat, barley. There is also a long ley treatment in which the land is left down for nine years in grass before being broken up for the same "testing" sequence of arable crops that alternates with the three-year leys. During the initial period for which results are available the long ley was limited to six years duration until the experiment was fully under way. Soil samples were taken at three-yearly intervals at the end of both the "treatment" and "testing" sequences. In the case of the longer ley the plots were sampled at the beginning and end of a six year period under grass.

A comparison of the organic matter content of the soil at the beginning and end of a six year period, comprising three years of treatment crops or leys and three years of potatoes, wheat, barley, shows that only very small changes have occurred. A common method of assessing the level of organic matter in the soil is to determine the amount of carbon in organic form by analysis and this figure multiplied by a factor of 1·72 represents the content of organic matter. Soil analyses at the beginning and end of a six year period ending with the "treatment" sequence showed that there was a small gain of 0·19 per cent organic matter after three years down to a ley grazed by stock and a small loss of 0·15 per cent after three years arable cropping. Both of these "treatment" sequences had been preceded by the three arable test crops. However, the corresponding analyses, before and after the six year period ending with the testing sequence, show that the small accumulation of organic matter after three years in grass has completely disappeared after the next three years of arable cropping. Thus, under a system of alternate husbandry with equal breaks of ley and arable crops, it appears that any small improvement in organic matter during the period in grass is balanced by a decline in the succeeding sequence of arable cropping. After six years of all arable cropping, admittedly on "conservative" lines with two root crops and a one year ley in the six year rotation, there has been a very small decline of 0·14 per cent in the level of soil organic matter. Clearly when the rate of change is slow, six years is too short a time to determine significant trends. However, samples taken from the plots which are down to grass for nine years show a much more clearly marked build up in organic matter. For example, in a heavy clay soil at Boxworth, the rise in organic matter from the third to the ninth year of a long ley was 1·29 per cent which is a really substantial improvement. A comparable increase in organic matter of just short of 1 per cent was also found on the "difficult" silty clay soil at Rosemaund, where grass farming is traditional and continuous arable cropping has been known to result in poor soil structure, possibly creating problems of tilth formation and uneven crop response to fertilizer.

It must be admitted that the valuable effect of a long ley in raising the level of organic matter in the soil is of rather academic interest to the arable farmer. What interests him is the rate of run down in a predominantly cereal growing rotation. Evidence has already been quoted to show that in a rotation with 50 per cent cereals the reduction in six years is very small. Some information about the effect of increasing the proportion of cereals to 66 per cent is to be found in the records of the Straw Disposal experiment to which reference has already been

made. After taking sugar beet, wheat, spring cereal, potatoes, wheat, spring cereal, the reduction in the percentage of organic matter has been very small (0·1–0·2 per cent) on a chalky silt soil, a light sand or a true silt soil, but slightly larger (0·5 per cent) at the centre on chalky boulder clay. These losses are very little greater than were found with the rotation having 50 per cent cereals. What is the effect of intensifying cereal growing even further? At High Mowthorpe on a chalky silt loam inherently high in organic matter, seven years of continuous barley growing has reduced the organic matter content from 4·25 to 4·00, quite a small decline. The important point is that after a fairly extended period of intensive cereal cropping, the organic matter on this Yorkshire Wold soil is still relatively high, compared with the figures of 2 per cent or less recorded on light soils even under mixed arable cropping. It is now recognized that good barley yields are possible for several years in succession on chalk soils in the southern counties or on Wold land. Such soils are inherently rich in organic matter and some loss in their reserves can be sustained before the danger limit is reached. On the other hand, the soil organic matter in much light land, even under varied cropping, approaches the 2 per cent point and problems are likely to arise on this land if cereals are grown intensively without any recuperative period in leys. The first indication of trouble on such light soils is the development, for no apparent reason, of "dead" patches where crop growth is feeble and cannot be improved by the usual remedy of extra nitrogen. Later more serious problems develop, such as Docking disorder of sugar beet, which occurs sporadically on light soils farmed on an intensive arable system with the minimum of livestock in the Eastern Counties.

The chalky boulder clay at Boxworth is well supplied with organic matter and at this farm winter wheat has been grown successively for 13 years. During this time there has been no evidence of any decline in organic matter status and the present level in the soil of 2·8 per cent is satisfactory even by heavy land standards.

Effect of Ploughing in Straw

Interest in the value of ploughing in straw dates from the time when the combine harvester, which left the straw on the land, began to displace the binder and corn stack. With the introduction of the pick up baler, clearing straw from behind the combine became less of a problem but, because of the labour of handling yard muck and the relative unprofitability of yarded cattle, an increasing number of farmers in arable areas have abandoned livestock, or at least no longer need straw for bedding, and are relying on the return of crop residues from an intensive arable rotation to maintain soil condition. Of these residues cereal straw is an important item and the problem of its disposal a very real one. If ploughed in straw could be shown to make any significant contribution to the reserves of soil organic matter, there would be a good case for the practice and a straw chopper would be almost essential because the presence of long straw hinders efficient stubble cleaning after harvest and makes it more difficult to maintain a good standard of ploughing with complete burial of trash. However, present evidence suggests that the return of straw to the land adds very little to the organic matter content of the soil. At the Norfolk Agricultural Station, Sprowston ploughing in straw every other year for 20 years only improved the organic matter content of the soil by 0·17 per cent. A similar increase in organic matter level was recorded at Rothamsted where higher rates of straw than those

used at Sprowston were ploughed in every second year for 18 years. More recently the results of analyses from experiments in progress at four Husbandry Farms show that in six years of arable cropping, including four cereal crops, the increase in organic matter reserves has been negligible. For example, at Gleadthorpe the organic matter on one set of plots in 1955 was 2·2 per cent and was exactly the same six years later after after a total of 4 tons of straw had been ploughed in. On heavy land at Boxworth the experiment started on a field with a relatively high level of organic matter of around 3 per cent. During the following six years, after a total of $4\frac{1}{4}$ tons straw had been ploughed back, the organic matter content had fallen from 3·1 to 2·6 per cent, a fall of 0·5 per cent which was identical with the decline on plots where all the straw was carted off. During the early years of the experiment to which these results refer, the quantities of straw returned were fairly small but for future rotations the amounts returned will be more comparable with the actual weights of straw normally grown. It may be that this change will result in a more rapid build up of organic matter. This is the view held by some intensive arable farmers who plough back all their straw and are convinced of the value of the practice in maintaining soil fertility. At present the weight of experimental evidence is against this belief, but this is not to be taken as a recommendation to burn or sell all straw not required for bedding. Although in the short term little gain in yield or benefit to organic matter reserves can be expected from ploughing in straw, in the long run organic matter is being returned whereas it is lost irrevocably if the straw is burnt. Dressings of dung may not produce much immediate improvement in soil organic matter content but there is little doubt as to its value on light land in a dry summer and it would be unwise to dismiss too lightly the long term benefits of retaining straw on the farm.

THE PRODUCTION AND FEEDING OF BARN DRIED HAY AND SILAGE

S. Culpin, *Drayton Experimental Husbandry Farm*

Experiments on the production and comparative feeding value of silage and barn dried hay are in progress at three Experimental Husbandry Farms; Bridget's in Hampshire (annual rainfall 30 in.), Drayton in Warwickshire (24 in.), and Great House in Lancashire (50 in.).

The methods used at the three farms have varied in details but the main principles have been the same, i.e., to cut a grass crop for silage and for barn hay on the same day in the same field, to assess the conservation losses and then to test the nutritive value of the fodders by feeding them to cattle. At Bridget's and Great House the cattle are dairy cows, at Drayton they are beef animals.

Yields of Edible Conserved Fodder

For barn hay drying the procedure has been to cut with a mower and encourage drying in the swath by the adoption of quick hay making methods which in most cases included the use of a machine such as a crimper immediately after mowing. If at all possible the hay was baled two days after cutting although on some occasions a longer period was necessary.

Most of the losses which occur in barn hay drying take place in the field before the crop is baled. At both Drayton and Bridget's the loss after baling, i.e., in the drier, has been only 2–3 per cent.

Most of the losses in silage making occur after carting into the silo. If the crop is wilted before ensiling there may be a field loss of about 5 per cent but in the case of direct cutting and ensiling this loss is negligible.

The total losses in silage making were similar at the three centres but for barn drying have varied considerably and although there has been potentially the same crop yield in the field there have been different quantities of dry matter available for feeding as shown in the following summary table.

Centre	Yield of dry matter for feeding (cwt/acre)		Increased yield from barn hay (as a percentage of the silage yield)
	Silage	Barn hay	
Drayton	29·3	36·0	23
Bridget's	22·2	26·0	17
Great House	26·8	29·3	9

This table illustrates that more food per acre was produced by barn dried hay than by silage at all three centres but at Great House with the highest rainfall the hay making losses were considerably greater than at Drayton with the lowest.

The Feeding Value of Hay and Silage for Beef Cattle

In the beef cattle feeding trials at Drayton the animals in different years varied in age from 8 to 20 months at the beginning of the winter feeding period. The cattle were either pure Hereford or out of a Hereford cross cow by a Hereford bull. They were fed either barn dried hay or silage to appetite. In some cases no other food was given apart from the fodder but in others there was an allowance of a simple mixture of concentrated food consisting of equal parts of barley, oats and field beans plus minerals.

In the table on page 7 the records from all the animals which received no concentrates have been grouped together and the same has been done for those that received 3 lb and those that received 6 lb per day.

Grouping the trials according to whether there was no concentrated food, 3 lb per day or 6 lb per day has brought out the differences between the two fodders and the effects of the combination of concentrates and fodders.

Considering Trials 1 to 5 when the cattle were fed no concentrates, it is shown in the two left-hand columns of figures that the cattle fed with barn dried hay found it more palatable than did their opposite numbers fed on silage. On average there was a difference of over 3 lb per day of dry matter between them. Before feeding to cattle the barn hay and silage had also been fed to sheep in cages and it had been found that there was very little difference in digestibility but a considerable difference in the appetite of the sheep which showed the same preference for barn dried hay as the bullocks. Thus, in Trials 1 to 5 the cattle on barn dried hay were consuming considerably more digestible nutrients than those on silage and it was not surprising to find that the former gained faster than the latter. Furthermore the animals given barn dried hay had an average

Trial no.	Average age (months)	Total appetite (lb dry matter per day) Silage *ad lib*	Barn hay *ad lib*	Liveweight gain (lb per day) Silage *ad lib*	Barn hay *ad lib*
			No concentrates		
1	20	13·3	17·7	0·6	1·7
2	20	16·5	18·3	1·5	1·8
3	20	16·2	20·4	1·4	1·8
4	8	7·3	11·0	NIL	1·2
5	8	8·0	9·8	0·6	1·2
			With 3 lb concentrate		
6	10	12·8	13·9	1·2	1·6
7	12	14·0	14·7	1·3	1·6
8	20	14·9	14·4	1·2	1·8
9	20	18·3	22·1	1·7	2·6
			With 6 lb concentrate		
10	10	14·0	14·1	1·7	1·9
11	12	15·5	15·4	1·8	1·6

food conversion ratio of 10 lb dry matter whereas those on silage had 15 lb dry matter per 1 lb liveweight gain. This difference is a natural consequence of the hay fed bullocks consuming more digestible nutrients and therefore having a larger proportion of their ration available for productive purposes.

When fed fodder alone the younger animals appeared to be at a disadvantage even on barn dried hay and their appetites (Trials 4 and 5) were not sufficiently high to achieve gains of more than 1·2 lb per day whereas older bullocks made up to 1·8 lb per day. With silage the gains were even more erratic. In Trial 4 silage was only a maintenance diet and in two others the gains were only 0·6 lb per day.

In Trials 6 to 9 the effect of feeding 3 lb of concentrates was to narrow the difference both between the appetites and the liveweight gains but even so there was still on average a greater consumption of barn dried hay and a greater liveweight gain by the animals eating it. The conversion ratio of the silage bullocks averaged 11·1 lb of dry matter and the barn hay bullocks 8·6 lb of dry matter per 1 lb liveweight gain.

In Trials 10 and 11 the feeding of 6 lb per head per day of concentrates eliminated both the difference in appetite and the difference in performance and therefore the conversion ratio was 8·4 lb of dry matter per 1 lb liveweight gain in each case.

The Feeding Value of Hay and Silage for Dairy Cows

Both at Bridget's and Great House, the fodders were tested by feeding to dairy cows in trials of the changeover type i.e., each cow had a preliminary period on a certain fodder and was then tested on that fodder. Subsequently it was gradually changed to the other fodder and then tested on the second fodder. Half the cows started on barn hay and half on silage.

In the Bridget's trial three fodder treatments, hay alone, silage alone, hay plus silage were combined with three concentrated food treatments, 4 lb per gallon

of concentrates above 1 gallon, above 2 gallons and above 3 gallons. In this report only the fodder treatments are discussed. At Great House there were two trials in one of which early cut barn hay or silage was fed in combination with concentrates above 2 gallons. In the other trial late cut barn hay or silage was fed in combination with concentrates above $\frac{1}{2}$ gallon per day.

Fodder appetites

The fodders were fed to appetite in each case.

	Dry matter (lb per day)		
	Barn hay	Silage	Hay/silage
Bridget's	31·1	21·8	22·2
Great House (early cut)	25·1	19·8	—
Great House (late cut)	18·4	16·4	—
The average concentrated food was as follows (lb per day)			
Bridget's	5·4	5·5	5·6
Great House (early cut)	6·7	6·2	—
Great House (late cut)	12·2	12·0	—

The feeding of concentrates showed only small variations due to individual differences in milk yield but there was a clear indication of increased dry matter intake by those cows receiving barn dried hay, particularly at Bridget's. Rather surprisingly, the allowance of 10 lb barn dried hay to the hay/silage cows at the same centre did not increase consumption to the extent that might have been expected.

Milk yields

The yields per day in the three trials were as follows:

	Milk (lb per day)		
	Barn hay	Silage	Hay/silage
Bridget's	33·2	32·4	31·7
Great House (early cut)	34·7	32·3	—
Great House (late cut)	33·9	32·5	—

There were only marginal differences in yields in spite of the considerable differences in fodder intake. By making due allowance for the concentrated food and for the conservation losses, estimates were made of the respective milk yields per acre.

	Milk (gallons per acre)		
	Barn hay	Silage	Hay/silage
Bridget's	309	364	378
Great House (early cut)	183	211	—
Great House (late cut)	84	45	—

Figures collected so far are rather inconclusive when considered on an acreage basis. There was a tendency towards more milk being produced by the silage.

Discussion

The conservation losses in making silage were very similar at all three centres but there were considerable differences in making barn dried hay so that the increased yield of dry matter from the latter varied from 9 to 23 per cent. At Drayton, where barn drying gave the best results and the feeding tests were done with beef cattle, it was shown that in the absence of concentrated food the use of barn dried hay increased liveweight gains per day and improved the food conversion ratio. It has been estimated that in the absence of concentrates the liveweight gain per acre was over 40 per cent more with barn dried hay than with silage. The feeding of concentrates at a rate of 6 lb per day equalized both liveweight gains and food conversion ratios and under these conditions the increased liveweight gain per acre was 23 per cent, a direct result of increased yield of conserved fodder as barn hay.

At the other two farms the dairy cows had a larger appetite for barn dried hay than for silage but this made no difference to milk yields and the increased consumption of food meant that one acre of barn dried hay provided on average less cow days per acre than the silage. Thus there was an indication that silage produced more milk per acre.

The difference between the beef cattle and dairy cows results can be explained to some extent by reference to an observation made at Bridget's i.e., that the silage fed cows lost 16 lb liveweight during the course of the experiment whereas the barn hay cows lost less than 2 lb per head.

It is therefore suggested tentatively that with beef cattle there is every advantage to be gained from increasing fodder consumption but with dairy cows free access to barn dried hay can lead to luxury consumption which puts on weight rather than increasing milk production. The milk production might still have been the same if the barn dried hay had been rationed to give an intake equal to that of the silage.

REARING OF SPRING BORN CALVES AT GRASS

P. J. Jones, *Bridget's Experimental Husbandry Farm*

Trials with autumn born calves carried out on Experimental Husbandry Farms during 1955–57, showed clearly the advantages of turning the animals out to grass as early in the spring as possible. By turning calves out before any appreciable growth of grass had taken place, they became gradually accustomed to their new environment and were better able to utilize the spring grass. As a result, they made a steady liveweight gain throughout the grazing season and avoided the check in growth usual when animals are turned out onto spring grass. An appreciable saving in hay and concentrates was made and a saving in labour was also observed. Most farmers believed, however, that calves born in the spring were not old enough to be turned out at all during their first summer, but if such calves could be reared successfully outdoors, then similar savings might be achieved. A series of trials was therefore started at four of the Husbandry Farms to determine whether it was possible to rear spring calves on grass and what savings, if any, in hay and concentrates could be made.

Bridget's

The treatments in these experiments varied a little from year to year, but showed a logical development. For instance, two years' work was sufficient to show that it was unnecessary to keep calves housed during the summer, so this treatment was replaced by one in which calves were turned out at birth, which again was subsequently modified to include a comparison of levels of concentrate feeding.

The calves were Ayrshire heifer calves born from the middle of February until early April. Those calves reared entirely outside were turned out within 48 hours of birth. Open-fronted shelters were provided, but the animals had free access to grass.

1958–59

Treatments	No. of calves	Liveweight gain (lb day)	
		Birth to mid summer	Birth to yarding
Housed all summer	13	0·82	1·16
Gradual turning out	13	0·96	1·27
Out from birth (1959 only)	7	1·12	1·45

1960–62

Turning out:	No. of calves	Liveweight gain (lb day)			
		Rearing period 1960–62	12 weeks to yarding		
			Concentrates (lb day)	1960–61	1962
Abruptly at 6 weeks	24	0·90	1½†	1·44	1·54
At birth with concentrates	24	1·02	3†	1·50	1·48*
At birth without concentrates	24	0·89	nil	1·26	1·28

* 1½ lb of rolled barley only in 1962.

† calves regrouped to make this comparison.

These trials showed that satisfactory liveweight gains could be obtained by rearing calves outdoors and that the best growth rate resulted from turning out at birth, thus avoiding a change in environment. With calves reared outside without concentrates, daily liveweight gains were reduced. This was not brought about by any check in growth, but was due to an overall slower rate of growth. These animals were small and pot bellied, and never looked as attractive as the others. However, from 12 weeks onwards they made a liveweight gain of 1¼ lb a day from grass alone, and finished the summer only some 30–40 lb lighter than the calves which had been reared on a higher level of nutrition. The feeding of

1½ lb concentrates a day increaed this rate of gain by about ¼ lb, but at the 3 lb rate of concentrate feeding only a slight additional liveweight was obtained, and there was no advantage in feeding at this higher rate.

In the one year in which it was tested, 1½ lb rolled barley gave liveweight gains almost equal to those obtained from the same amount of balanced concentrates.

1960–62 *Food costs*

Turning out	Rearing period	12 weeks to yarding		Total	Weight at yarding
		Concentrates			
	£ s.	lb/day	£ s.	£ s.	lb
Abruptly at 6 weeks	5 14	1½†	2 18	8 12	380
At birth with concentrates	5 14	3†	5 16	11 10	386
At birth without concentrates	3 1	nil	19	4 0	349

† calves regrouped to make this comparison

These results showed that by rearing at grass, food costs could be markedly reduced. For heifer calves the reduced weight at yarding is not an important factor.

Few deaths occurred during the trial periods, but it soon became obvious that outdoor rearing demanded a high degree of management and stockmanship. The biggest problem was scouring which occurred in most years, usually in May. This was treated by dosing with kaolin. In 1961, dung samples showed a build up of stomach worms, and so the calves were dosed with phenothiazine, and moved to clean pasture, when the trouble cleared up. In 1962, rotational paddock grazing was practised and a serious build up of worms avoided. However, one case of coccidiosis occurred, which was treated with sulphamezathine. Bloat and husk were not normally encountered.

Outdoor rearing led to some practical difficulties, the most important of which was the transporting and feeding of *warm* liquid food for the first 5–8 weeks of the calves' lives. This was achieved by mixing the substitute in a concentrated form in cold water and diluting with hot water carried out to the field in churns. On other farms, where large numbers of calves are involved, special insulated tanks have been developed but this is difficult to justify on a small scale. Because of this difficulty it might be better to rear the calves in a field adjoining the farm buildings, so that the warm gruel could be fed under cover.

Great House

Similar work has been carried out at Great House Husbandry Farm again using Ayrshire heifer calves.

In 1959 five calves born in March and April were reared on whole milk for three weeks. During this time early weaning nuts were offered and hay and water were always available. They were turned out to grass on 28 May, when they were between 40 and 80 days old. Early weaning nuts were fed increasing to 5 lb a day, but these were eventually replaced by a cheaper ration fed at 3 lb a

Outdoor rearing of Ayrshire heifer calves

	1959	1960		1961	1962
No. of calves	5	6	5	12	6
Date of turning out	28 May	16–27 May	Housed	2–16 May	7–21 June
Liveweight gain (lb/day)	1·85	1·35	1·35	1·25	1·40
Food cost per calf	£12 9*s.*	£8 16*s.*	£15 3*s.*	£9 7*s.*	£7 4*s.*

day throughout the summer. By mid-October the calves averaged 373 lb liveweight, and had made a liveweight gain of 1·85 lb a day. This was very satisfactory, and was greater than any gain previously achieved by heifer calves reared inside. In 1960, the performance of calves housed all the summer was compared with that of calves reared outdoors. Concentrates for the outdoor calves were discontinued after 12 weeks of age, while the housed calves continued to get 3 lb a day plus hay fed to appetite. In spite of receiving no hay or concentrates after 12 weeks of age, the calves reared outside put on the same gain per day as those reared indoors, and a saving of £6 7*s.* per calf was obtained. When compared with the calves reared out of doors in 1959, the reduction in concentrate feeding after 12 weeks reduced daily liveweight gain by about ½ lb a day.

In 1961, results similar to those of the previous years were obtained; although the liveweight gain was only 1·25 lb a day, an estimated saving of £9 per calf was made.

In 1962, heifers reared outdoors gave a liveweight gain of 1·40 lb a day, and a saving of £8 5*s.* per calf was obtained over the estimated cost of indoor rearing.

These four years' results indicate that satisfactory growth rates and considerable savings in cost can be obtained by turning calves out to grass at about five weeks of age. A study of individual gains showed that calves turned out at the beginning of May grew faster than those turned out later in the month, but that the turning of calves out to grass under five weeks of age could not be recommended under the conditions prevailing at Great House. There appeared to be no advantage in continuing to feed concentrates after twelve weeks of age.

Liscombe

The practice at Liscombe is to buy Devon × Friesian bull calves at 4–7 days of age in February and March. Feeding is based on the use of reconstituted skim milk powder at the rate of 1 lb milk powder to 1 gallon of water. For the first two days after arrival, the calves are fed four pints, which is gradually increased to eight pints a day, given in two feeds.

The calves are normally bucket fed, but some experience has been gained in the use of a calf feeder in which the milk substitute and warm water are mixed automatically. The machine is based on an electrical mechanism which regulates the mixing and feeding on a continuous cycle. Batches of 12 calves have been reared quite successfully, both inside and at pasture, and it is considered that

this number could be increased to at least 15 in each batch if care is taken in the early stages of rearing to see that all calves have an opportunity to get accustomed to the feeding teat.

From ten days of age calves have free access to an early-weaning concentrate and a little good quality hay or silage. Calves are weaned abruptly on reaching 130 to 140 lb live weight at approximately 6 weeks of age. They are then turned out in an open yard for a short while each day for 2–3 days, and then out to pasture completely. No shelter is available other than that provided by the typical West Country banks and hedges.

The calves are turned onto pastures which have not carried cattle or sheep during the previous 4–6 months in order to keep parasitic infection as low as possible.

The feeding of early-weaning concentrate is continued until 8–9 weeks of age. The expensive ingredients are then gradually excluded so that the ration consists of equal parts of maize flakes and cereal, restricted to 3 lb/head/day.

When the calves reach around 200 lb live weight at approximately 12 weeks of age, concentrate feeding is stopped and they rely on grass alone until late autumn and up to early December as long as good quality grass is still available.

This system of rearing calves has been practised on the farm for a number of years and has proved quite satisfactory as is shown in the following table:

Spring-born Devon × Friesian steer calves
average performance over 4 years (148 calves)

	Food offered	Liveweight gain (lb/day)
Stage 1 Indoors to weaning 1–6 weeks.	Milk substitute, concentrates, hay or silage	1·0
Stage 2 Outdoors 7–12 weeks.	Concentrates, grass	1·3
Stage 3 Outdoors 13–28 weeks.	Grass only	1·7

The weight range of spring born calves, reared under this system has varied by the following autumn, from 3 to 4½ cwt, with an average of 3½ cwt. Concentrate feed costs have averaged £4 10*s*. per calf, which includes the cost of dried skim milk powder, concentrates and a small allowance for roughage fed during the indoor rearing period, to which must be added the cost of growing grass. Calves are run at a stocking rate of 4 per acre. The requirement during the early stages of rearing is very small and silage making plays a large part in grassland management in the system. Experience has shown that, at this stocking density and with moderate fertilizing, between 1½ and 2 tons per acre of silage are made from the calf area. From July onwards each calf required its full allocation of ¼ acre for grazing.

The results of an experiment to study the response to supplementary feeding calves reared at grass from approximately 6 weeks of age, suggest that any advantage gained from such feeding has not been economic. Calves were reared, by the method described previously, until they reached a live weight of between 190–220 lb. They were then split into 3 groups, each of 8 calves. One group

was on grass only, the second group allowed 2¼ lb per day of rolled barley and the third group 2¼ lb per day of a 3:1 mixture of barley and high-protein concentrate.

The value of supplementary concentrate feeding to calves at grass

Group	*Liveweight gain (lb day)*
Grass only	1·59
Grass + 2¼ lb/day rolled barley	1·55
Grass + 2¼ lb/day barley/protein concentrate	1·80

Over the 3 years of the trial, there was no response to barley feeding and less than ¼ cwt additional live weight from the feeding of 2¼ cwt of the barley protein mixture in a feeding period of 112 days.

The concentrates were individually fed in this experiment but, as all the calves were grazed in the same field, it is likely that those given supplementary feed ate less grass which was, of course, not measured.

The performance of spring-born calves, reared for the greater part of the first 6 months of their lives at grass, compares favourably with indoor rearing. There are, however, certain points on management which need careful watching: particular attention is paid to ensure that grass quality is good and quantity adequate during the whole of the grazing season.

Young calves have little immunity to parasites, and certain precautions are taken. These include the practice of turning calves out in batches onto a parasite-free pasture. In this way, starting off with a low infection, the calves will usually build up their own immunity.

High Mowthorpe

In 1961 an experiment was started to compare indoor rearing of Friesian steer calves with rearing outside from birth both with and without concentrates. Early weaning at three weeks with calves outside on grass was not successful and mortality was high; feeding milk substitute for a longer period on grass reduced these losses. However, over the whole period, liveweight gain was highest from the calves receiving concentrates while reared at grass. Those without concentrates did not do at all well.

The experiment was repeated in 1962, again with purchased Friesian calves, although weaning was delayed until the calves were 5 weeks old. Instead of a group housed all summer, they were housed only for approximately 6 weeks before being turned out. Concentrates were continued up to 12 weeks. The health of the calves was better, and only 3 were lost. Liveweight gains showed an improvement over 1961, but again the no concentrate group was lower than the others. Rearing indoors for the first 6 weeks gave slightly the better rate of gain.

The comparison in 1963 was between calves reared inside for about 5 weeks before going out to grass, when they continued to receive concentrates for a 12 weeks period, with another group which was reared at grass without concentrates. Later 1 lb of rolled barley was fed each day as a carrier for a mineral supplement. The calves early weaned indoors before being turned out to grass did considerably better than those put outside on arrival.

In this trial an attempt was made to compare the pure Friesian with Hereford Friesian cross. The Hereford cross calves were inferior to the Friesians.

Conclusions

Grass can be made to reduce rearing costs both for heifer calves intended for herd replacements and steer calves for beef. Only at Bridget's, however, was outdoor rearing from birth really successful, and even here the practical difficulties of carting warm liquid food to animals made the method of doubtful value to all but a few enthusiasts. On balance it would seem best to rear indoors, weaning at 5 weeks and turning out to grass at 6 weeks, and continuing concentrates at 1½–2 lb a day until the animals are about 12 weeks old. From then onwards grass alone is sufficient.

All farms have shown the need of good grassland management and the need to avoid a build-up of worms; otherwise severe scouring and death occurs.

SHEEP HUSBANDRY

D. A. Perks, *Drayton Experimental Husbandry Farm*

In the 1961 Progress Report articles by both Davies and Longrigg concerning sheep management referred to work completed and in progress on the Experimental Husbandry Farms. The purpose of this article is to review subsequent developments.

Intensive Methods of Sheep Grazing

This trial has now been concluded and a full account will be published shortly in *Experimental Husbandry*. At Boxworth, Drayton, Liscombe and Trawscoed there were comparisons of set-stocking with rotational forward creep grazing and rotational sideways creep grazing. At each centre stocking rate was chosen in the light of local experience, but in each year all grazing systems at any one centre were stocked at the same rate.

The system of grazing management had no consistent effect on the lambs' rate of liveweight gain. Regardless of system, the lambs seemed capable of near-maximum rates of liveweight gain per day for the first 10 or 12 weeks of life, but beyond this point the rate of gain declined. The object of rotational grazing with a creep is to keep fresh, good quality grass available to ewes and lambs for a long season and to give the lambs preference over the ewes, thus allowing them to achieve better growth rates. Unfortunately the problem of matching the grass output with the animals' feed requirements was only partially solved. If in any one year the stocking rate was too low to utilize all the grass produced in the May flush, the pasture quickly became mature and lamb performance suffered. If a stocking rate heavy enough to control the pasture during the flush period was used, it tended to be too high in late June and July.

At Boxworth and Liscombe where lambs were not drawn for sale during the course of the trial, there was no difference in rate of liveweight gain between treatments at the end of the season. Neither was there evidence from any of the four centres that the treatments gave rise to differences in the amount of liveweight gain made by the ewes, the fleece weight of the ewes, or the level of parasitic worm infestation in the lambs.

At Drayton and Trawscoed lambs were drawn for slaughter as they reached a predetermined live weight, and the ewes were also withdrawn as soon as their

own lambs had been sold. It was at these farms from June onwards that the forward creep system showed some advantage. The lambs were then about 12 weeks old and, as the ewes' lactations declined, they were becoming almost totally dependent on grass at a time when its quality and vigour were beginning to decline. Because of better utilization on the forward creep system the onset of this decline in grass quality was delayed and an advantage bestowed on the lambs. The advantage tended to be cumulative because forward creep lambs were sold earlier and the stocking rate on their pasture reduced so that the remaining lambs had a better chance.

It should be emphasized that the delay in the onset of declining liveweight gain on forward creep grazing systems in these conditions is only temporary. Particularly in the lower rainfall areas it will be advantageous, as soon as possible, to allow the lambs extra ground, probably in the form of conservation aftermaths, in order that, as the season advances, paddocks may have longer rest periods. Whether this area can be allowed for as an integral part of the creep-grazing paddocks or requires another field to which the stock are moved, will depend on the individual farm.

In a subsequent trial at Drayton forward creep grazing and set stocking were compared at varying stocking rates. In this trial the advantage of forward creep grazing was assessed in the form of an increased stocking rate, rather than as an increase in the rate of fattening of lambs. In each of two years, lambs on a forward creep system at a stocking rate 20 per cent higher than those on set stocking made a liveweight gain per day only fractionally lower. Increases in the stocking rate of the forward creep system beyond this point, although giving yet greater output of lambs per acre, reduced individual lamb gain so that there was a lower proportion of lambs reaching fat weight.

During the course of the above work it was apparent that in July, when the majority of fat lamb was sold from Drayton, the price realized was little greater than that for forward stores in the local September sales. It is probable that there is money to be made by a limited number of farmers keeping sheep intensively on a forward creep system for the production of store lambs, the extra numbers compensating for the lower return per animal.

It has sometimes been claimed that rotational grazing systems afford some protection against stomach and intestinal worms due to the periodic resting of the paddocks. Unfortunately a rest period which is long enough to affect the worm cycle is too long for the production of good quality grass and in the experiments there was no evidence of reduced infestation due to rotational grazing.

Autumn Fat-Lamb Production

At High Mowthorpe on the Yorkshire Wolds the intensification of a traditional flock, formerly set-stocked at 3 ewes per acre, has recently been accomplished by using grass heavily stocked on a forward creep system in summer to produce cheap store lambs, not for sale but for fattening in autumn or winter.

The autumn fattening has been achieved in several ways. In September and October lambs were either on grass and stubbles or folded on specially grown rape and Italian ryegrass. In November and December half the lambs from off the grass and all those from the rape went on to folded kale and turnips, while the rest of the grass lambs were housed and fed on either all barley or silage

plus barley. The margin per lamb over food cost, plus initial valuation, varied between 25*s*. for those finished on all barley, and 42*s*. for those finished on kale and turnips. The relatively high cost of the all barley ration reduced the margin per lamb on this treatment, while the highest margin was achieved where lambs were stocked for a short finishing period on roots after previously grazing on the cheap by-products of cereal growing.

At Great House Experimental Husbandry Farm in the autumn of 1961 and 1962 trials were conducted on various systems of feeding store lambs to slaughter weight. The highest margin in both years was from animals kept at grass and offered up to 1 lb concentrates per head per day. Lambs tended to refuse whole maize, but readily ate a home-mixed dairy ration and were trained to accept rolled barley in time. Indoor feeding on slats was less profitable because of the check when the animals first came in and because of the higher concentrate intake found necessary to maintain the same rate of gain as that made by the outdoor lambs.

A feature of the autumn lamb fattening trial at the Husbandry Farms has been the disappointing liveweight gains obtained. These varied from:

0·16 to 0·26 lb per day with Suffolk × Half bred lambs at High Mowthorpe;

0·10 to 0·24 lb per day with Derbyshire Gritstones at Great House;

0·19 to 0·34 lb per day with Suffolk × Half bred lambs in a preliminary study at Drayton.

Stocking Rate and Nitrogen Usage

The scope for intensification afforded by increased use of nitrogen fertilizers is the subject of a trial started in 1963 at Bridget's Husbandry Farm. Three farm units of 13½ acres each have been created which receive respectively 50 units, 150 units and 250 units N per acre per annum. The units must support the ewes allocated to them, and their lambs, for the whole of their lives, and to this end about 60 per cent of the total area of each unit was divided into paddocks for forward creep grazing. The remaining 40 per cent was conserved as silage in clamps, made separately on each treatment, for feeding to the ewes in winter.

The stocking rates chosen originally were 3, 4 and 6 ewes per acre on the low, medium and high N treatments respectively, but for the second season this has been reduced to 5 ewes per acre on the high nitrogen treatment. It should be emphasized that the stocking rate is a consequence of the nitrogen treatment, and not vice-versa, and stocking rates are to be adjusted annually, as the swards develop, to ensure full utilization. The final evaluation of this trial will be in financial terms. All inputs of land, labour, shearlings, machinery and materials, and all outputs of lamb, wool, cull ewes and spare conserved products, will be costed for each unit separately. Thus the profitability of using different levels of nitrogen for an intensive system of fat lamb production will be assessed.

Winter Housing of Sheep

Such systems as are in use at Bridget's and High Mowthorpe may prove well worthwhile where sheep can be wintered satisfactorily out of doors on grass and silage or roots at high stocking rates. But this is not universally possible and has led to investigations into the feasibility of housing sheep in winter. The first of

these investigations took place at Pwllpeiran, the Husbandry Farm on the slopes of Plynlymon, where the object was to evaluate systems alternative to the traditional one of sending ewe-lambs away to the lowland for their first winter. This practice was becoming continually more expensive, and good lowland wintering even more difficult to obtain, as the dairy cow extended its sphere of influence further into the foothills. The initial comparison was between away wintering on "tack", folding on roots or roots and hay, each with a runback onto grass, or inwintering in a slatted floor shed with a diet of hay only. As the performance of the group on long hay was unsatisfactory this was later replaced by cubed hay, and a cubed hay plus concentrates treatment was also introduced.

Generally the ewes sent away on tack made the greatest liveweight gain during the winter and again during the following summer. However it was shown that lambs could be satisfactorily wintered at home on kale and swedes, or hay, kale and swedes, for 7*s*. 6*d*. to 12*s*. 6*d*. per ewe less than the cost of tack. Wintering on cubed hay cost the same as tack. Although home wintering on roots and hay offered apparent savings, the true cost can only be assessed by the effect on the economy of the farm as a whole. Home wintering of ewe lambs was done by grazing the in-bye land in the autumn and feeding the roots in the more severe weather later; these ewe-lambs were therefore competing with in-lamb ewes for limited food supplies with a possible reduced lamb crop in consequence. It is considered that it would probably be more remunerative to continue to winter ewe-lambs away or at home in sheds, and to use the available root acreage to increase the number and productivity of the mature ewes on the farm.

The idea of housing sheep was extended to the inwintering of in-lamb ewes at Drayton. It was felt that the factor limiting the intensification of sheep enterprises on clay soils was very often inability to carry as many ewes in winter as could be carried in summer. The problems in winter are excessive poaching, with suspected reduced output from the grassland in the following spring and discomfort of the ewes feet, in addition to the quagmire invariably associated with field hay racks and the poaching by the wheels of vehicles coming to replenish them. With these considerations in mind, experiments were started in 1960, when 84 in-lamb Half-bred ewes were housed from mid-December until lambing in mid-March. Satisfactory results in this season encouraged an expansion of the work so that by the 1962–63 winter over 300 ewes were wintered indoors. There are now many other people trying the method, including Rosemaund Husbandry Farm.

The early results showed that ewes could be inwintered satisfactorily at a density of one ewe per 9 sq ft with no exercise beyond that which they got within the pen. Ventilation had at all times been more than ample and this was probably the main reason why respiratory diseases or a tendency to shed wool were never encountered. The original slats used were cut from $1\frac{1}{2}$ in. $\times$ $1\frac{1}{2}$ in. timber and others cut from 3 $\times$ 1 in. timber. Both have worked equally well with a $\frac{3}{4}$ in. gap between slats and efficient extensions to the slatted floor area have been completed in 2 $\times$ $1\frac{1}{4}$ in. softwood neither shaped nor planed, as these seemed unnecessary refinements. Ewes kept on straw litter have not proved to be particularly prone to footrot as long as the litter is kept dry and any animal seen with signs of foot trouble is isolated immediately. Occasionally ewes on straw have been sore between the toes where straw has irritated them, but this generally disappears within two or three weeks of the start of the winter.

Feeding at Drayton has been on hay and water with mineral licks. Inwintered animals consume about 4 lb per head per day until just before lambing, which is $3\frac{1}{2}$ cwt in 90 days. This is a maximum of 1 cwt per head more than outwintered animals. The difference is least in very hard winters, but of course the poaching damage due to winter grazing is also least in hard winters.

Normally, outwintered ewes have gained slightly more body weight than inwintered ewes over the period between the start of inwintering and just after lambing. They have also invariably produced heavier lambs; the three-year average birth weight of twin lambs born to outwintered ewes was 11·4 lb which is 0·8 lb heavier than twins born to inwintered ewes. During the three years casualties among ewes and lambs have been at a very low level and the true lambing percentage $\left(\frac{\text{lambs alive at 6 weeks} \times 100}{\text{ewes put to tup}}\right)$ has been 171 per cent for outwintered and 178 per cent inwintered ewes.

At 9 sq ft per ewe there is no room for lambs as well and, as soon as ewes lamb, they and the offspring have been removed from the pen, weighed and then turned out to pasture. This has been perfectly satisfactory in a flock where lambing time is not much in advance of the beginning of grass growth in spring. For early lambing flocks housed indoors this floor-space allowance would have to be greatly increased to accommodate the lambs as well in the later part of the winter.

Records show no differences in the subsequent summer performance of single or twin lambs born to ewes inwintered or outwintered. An attempt has been made to measure the difference in pasture productivity in the spring and summer following winter grazing or winter saving. This has been done by stocking with ewes and lambs and following the rate of lamb liveweight gain, but other factors, particularly stocking rate in relation to rainfall and nitrogen usage, influenced liveweight gain per day more strongly than the relatively small differences in pasture productivity that it was desired to measure. The difference no doubt exists and may be shown by more refined techniques in the future.

Thus the features of inwintering in-lamb ewes are:

a higher requirement for winter fodder;
an increase in grass output in spring, the size of which has not yet been established;
greater convenience of shepherding which, under some conditions, might lead to less mortality.

These have to be set against the cost of housing and extra feeding. If housing and feeding are not simple and inexpensive the advantages might easily be over emphasized and the method prove economically unattractive.

MODERN TECHNIQUES WITH CHRYSANTHEMUMS

A. D. Harrison, *National Agricultural Advisory Service, Wye*

The development of the Experimental Horticulture Stations coincided with a number of major changes in the methods of producing commercial chrysanthemum crops and as the crop, if one includes all methods of production, is the most important flower crop in the country, it was only to be expected that experimental work on it should receive high priority. Some aspects of production

have been and are being studied on every station and in several cases all stations have carried out the same experiments, so that the results can be interpreted from a national as well as a regional point of view. A total of 34 experiments and other studies on chrysanthemums have been undertaken. All stations are also interested in variety trials and these continue from year to year. A list of standard varieties has been compiled covering a limited colour range and varieties which flower in the months of August to December. Varieties which are considered promising from a commercial point of view are grown under the same conditions as the standards and assessment made of their commercial qualities. If a variety on trial proves to be better than the standard, it will replace it on the list. The present list is as follows:

1st earlies—August: White Hope Valley, Delightful, Tonedale, Red Flare, Packwell.

2nd earlies—September: Summer Snow, J. R. Johnson, Pink Pride, Cotswold Flame.

Early midseason—October: Maestro, Marie Brunton, Silver Dollar, Hugo, Leader.

Midseason—November: Ron Shoesmith, Golden Princess Anne, Loveliness, Working Scarlet, Stylish.

Lates: White Favourite, Yellow Fred Shoesmith, Sussex Pink, December Red, Balcombe Perfection.

A new approach to variety testing started at Stockbridge House in 1962. All the principal chrysanthemum raisers were asked to name the novelties which they considered might have a commercial future. A small quantity of each was then purchased by the Director and the varieties were grouped according to the raiser's recommendation and grown under reasonable commercial conditions. A panel of growers and N.A.A.S. officers visit the trials periodically and make an assessment of the varieties. As a result, they are placed in one of three categories.

(1) Worthy of extended trial at other stations.

(2) Have possibilities and warrant further trial at Stockbridge House.

(3) Rejected as showing no improvement on existing varieties.

It is intended that this method of testing varieties will continue over the years and the results will be made available to growers as soon as the trials have been in progress long enough to enable fair comment to be made.

Some of the more interesting and useful results obtained from experiments and observation studies which have been carried out to investigate modern techniques are discussed below.

Early Varieties in the Open

The first experiment on the effect of propagation methods on the ultimate crop was carried out in 1953 and 1954 at Fairfield, Luddington and Stockbridge House. The results are written up in detail in *Experimental Horticulture No. 1.* Briefly, the results showed quite clearly that by bedding out rooted cuttings at 4 × 4 in. on 2½ in. of J.I.P. Compost in a cold frame, the best and most productive plant is obtained. Rooted cuttings potted either in clay pots or in soil blocks were only slightly inferior but cuttings rooted at the same time and left in seed

boxes at a spacing of $2\frac{1}{2} \times 2$ in. produced very inferior plants. No economic study was made on this experiment, but there is no doubt that the extra work in bedding out in frames and in planting out plants raised in this way is fully justified.

Other experiments carried out at Efford, Fairfield, Luddington, Rosewarne and Stockbridge House were concerned with the effect of the date of propagation and of planting out. These results are recorded in *Experimental Horticulture No. 8*. It was considered that, by rooting cuttings later and planting more closely, production per sq. yard would not be seriously affected and that costs of production, because of the shorter life of the crop, might be reduced. While satisfactory crops were produced from later rooted cuttings, it was found that costs, mainly because of the increased number of plants required, tended to be slightly higher than when the plants were grown in the traditional manner. Further experience suggests that while the date of flowering is not noticeably delayed in a good summer, the flowers from late rooted cuttings may be three or four weeks behind schedule when summer temperatures are low. The effect of this delay is unpredictable. It may mean that the flowers are marketed in a better or a worse time as far as prices are concerned but with varieties normally flowering in the first half of September, it certainly increases the risk of the flowers being damaged by the weather.

In 1961, an experiment to check the economics of plant spacing of early flowering varieties was started at the Lee Valley Station. Plants were set out at 9×6; 9×12 and 9×18 in. and in the three years during which the experiment has been conducted, the returns per square yard have been consistently in favour of the closest spacing. In general terms, plants spaced at 9×6 in. have given at least as many top grade blooms as plants at the wider spacings and have, in addition, produced many more marketable blooms per square yard. These results are interesting and should have some effect on commercial practice as at present most growers allow at least 12 in. each way between plants. In the same experiment it has also been proved conclusively that "counting down" and removing what are considered to be unnecessary breaks has no effect on the quality of bloom produced.

Early Varieties Under Glass

Because of the need to produce high quality blooms unmarked by weather damage, and as a means of utilizing glasshouse space previously occupied by tomatoes, the area of early chrysanthemums under glass on commercial holdings has increased considerably. The main interest on the stations has been to compare varieties for their suitability for this method of growing, both in heated and in cold houses, and to study the effect of stopping on the time of flowering. The effect of stopping early varieties as compared with growing them on a single stem has delayed the time of flowering by about 10 days. This delay is difficult to assess from an economic point of view but, as a general rule, stopping once to produce 3 or more flowers would appear to be a sound commercial recommendation.

The more northerly stations have been especially concerned with production in cold houses, while at Efford the crop has been grown with some heat. Varieties which have performed well in heated houses include Golden and Orange Sweetheart, Delightful and Golden Delightful, Pennine Snow, Daphne Lewis and

Tonedale, while in addition to those listed, White Hope Valley, Milestone, Alice K. Johnstone and Globemaster have done well under cold house conditions.

October Flowering Varieties in Mobile Rotations

The chrysanthemum is an almost indispensable crop in mobile rotations and in one year from one to five crops can be covered at some time during their life. October flowering varieties have been grown to a considerable extent at Luddington and of those grown, Hugo, Bill Walters, Amy Shoesmith, Maestro and Stuart Ogg and its sport have given the best economic return. Many other varieties are suitable and in most years this particular crop, flowering as it does when outdoor flowers are likely to be cut by frost, can pay off handsomely. The crop is planted in the open, covered only in the four or five weeks prior to marketing and as a rule no heat is provided, which all adds up to efficient and economical production.

Late Rooted Mid-Season and Late Varieties

The technique of planting cuttings rooted in May, June, July and even early August is now almost standard practice on most commercial holdings. This method has largely taken the place of cultivation in large pots, in which cuttings rooted in March were potted on several occasions and eventually flowered in 8–10 in. pots which were moved into the glasshouse from mid-September onwards. The cost of production, using this old method, are so high that it is extremely difficult to show any margin of profit, even on a well grown crop. Using late rooted cuttings the time between planting and marketing is much reduced and, for this reason, fewer problems arise. The quality of bloom and especially the foliage compares favourably with those produced by the traditional method.

A number of experiments and observation studies concerned with this technique have been and are being conducted. They include investigations into the latest practicable date of rooting cuttings to ensure that an acceptable stem length and quality bloom are produced. The effect of spacing and levels of nutrients have been studied at Stockbridge House. Extra space gave improved quality and forwarded the date of flowering slightly, but it is doubtful if the extra quality and earliness fully compensate for the reduced number of marketable blooms per square yard.

One of the main problems, in a tomato/chrysanthemum rotation under glass, is to get the maximum yield from the tomato crop by leaving it in the house as long as possible without risking damage by an early frost to the chrysanthemums which are still unprotected. A number of the experiments at Fairfield have been carried out with the object of proving the most effective method of growing chrysanthemums to achieve this end. In 1961, a variety of containers including clay-pots, whalehides and peat pots were used. One rooted cutting was planted in each on 18 July and a comparable batch of rooted cuttings were planted direct into the glasshouse border. The pots were kept outside until 20 September and then planted at a spacing of 9 × 9 in. in the glasshouse. All plants were stopped to give three breaks. The quality of the direct planted crop was better than that obtained from either of the pot treatments but of those grown in containers, peat pots gave the best results. A short summary of present

recommendations for this method would be to pot up singly in peat pots not later than mid-July and plant into the glasshouse not later than mid-September. It is essential that late rooted cuttings are grown without a check as the short growing season does not give them a chance to recover fully from any checks to growth that occur.

An alternative method which has been used at Fairfield and Cleppa Park is to pot up three rooted cuttings in a 9 in. whalehide not later than mid-July. These plants are stopped once and produce an average of three flowering stems i.e., nine blooms per pot. An important point in relation to traditional growing in pots is that the plants produced by using late rooted cuttings are much shorter. This means that they are more easily handled when being moved into the glasshouse, that management at all stages is easier and that the shorter plants can be housed in houses which would be unsuitable because of insufficient headroom if the plants had been grown in the traditional manner.

Controlled Flowering of Crops for the Christmas Market

A large proportion of the crop produced from late rooted cuttings is grown to meet the demand for flowers at Christmas. Some of the most popular varieties e.g., Fred Shoesmith and its sports, tend to flower in early December. The use of electric light, either continuous or interrupted, to extend the day and prevent bud initiation, is frequently practised by growers, and experiments to test the relative merits of the two forms of lighting have been carried out at Luddington.

In continuous lighting, the day is extended by 2–3 hours from mid-August to late September and this prevents flower bud initiation until lighting is stopped. With interrupted lighting, the extended day commences at the same time, but is stopped about mid-September and restarted for another 10 days near the end of the month. The results indicate that while each method is effective in delaying the initiation of the flower bud, the claim made for improved quality from plants receiving interrupted lighting has not been proved. There was no significant difference in the number of petals per bloom and this is considered to be one of the main factors in assessing quality.

Production of Quality Flowers in January, February and March

It is very difficult to obtain good quality blooms during the above period because of the poor light conditions which obtain at that time. Several experiments have been carried out at the Lee Valley Station to find an answer to this problem. Growing at 58 F until buds are visible and then reducing the temperature to 52 F until the crop matures has had a very definite effect on quality of bloom but this benefit has been obtained at the expense of a fortnight's delay in flowering and a less uniform crop.

During the winter of 1962–63 an observation on the enrichment of the atmosphere with CO_2 was carried out. CO_2 was introduced into the glasshouse in sufficient quantity to raise the level to about three times normal. It was applied only during the hours of daylight and for not more than 8 hours per day. No ventilation was given in January and February so that there was little loss to the outside atmosphere. Treatment commenced soon after the plants were set out in their flowering quarters and was continued until marketing commenced.

The treatment had a marked effect on quality, particularly in petal substance and depth of bloom, petal numbers being increased by 14–20 per cent. This limited experience coupled with that on growers' holdings, suggests that the proper use of CO_2 may go a long way towards solving the problem of poor quality in the early months of the year. If the economic results at the Lee Valley Station can be taken as a guide, the investment in CO_2 and the equipment to distribute it in the glasshouse on a crop of chrysanthemums flowering from January to March will be amply repaid. Another interesting effect of CO_2 enrichment during the same period was noted on a growers' holding. Due to weather conditions and somewhat inadequate heating systems, it became quite impossible in January and February to maintain the optimum temperature of 58 F. The introduction of additional CO_2 kept flowering more or less on schedule whereas, in otherwise comparable houses, crops were three to five weeks late.

Year Round Production

With the introduction of this technique from the U.S.A. in 1955 it was decided that a comprehensive experiment should be carried out on all stations. Apart from obtaining knowledge of this method of growing, it was felt that some knowledge of the behaviour of the same variety under the range of conditions provided by the stations would be of value. This approach was warmly supported by the main producers of cuttings to whom the information obtained has proved extremely valuable.

Year round production in its fullest sense means planting every week of the year, with the natural result of cutting and marketing in the same way. It was felt that, to simplify the experimental lay-out and the management of the crop, it should be grown as three distinct "spot" crops during the course of the year. The respective crops were planted on 6 January, 20 May and 28 August and in all cases cut and cleared in time to prepare for the following crop.

The suitability of a variety may vary considerably according to the time of year and while 18 varieties were included in each crop, the total number of varieties grown was 40. Of these, 18 were varieties which were disbudded to give one bloom per stem and 22 were spray types.

The results obtained were particularly good in those crops maturing at end of July, but crops maturing in December and April, especially at Fairfield and Stockbridge House, the more northerly stations, were only fair. Of those tried, the English varieties Shirley Late Red and Loveliness proved unsuitable, while Poinsettia, an American introduction grown in the winter, took too long to come to flower.

The principles underlying the control of flowering in chrysanthemums which enables year round production to be achieved have been described so often that only a brief outline is necessary. With suitable varieties, bud initiation is prevented when the hours of daylight exceed $13\frac{1}{2}$. A low light intensity will achieve this objective, and 60 w. bulbs spaced at 6 ft intervals over the crop give sufficient light for the purpose. An alternative arrangement of bulbs giving a higher or lower output at wider or closer spacing will serve equally well.

To look at the matter from another angle, plants can be induced to initiate and develop buds if the hours of daylight are reduced to $10\frac{1}{2}$ or less. This is achieved by covering the beds completely with either black cloth or black

polythene. In the main experiment on year round or controlled flowering, the relative merits of the two materials were studied. Cloth will last much longer than 150 gauge black polythene, but the cost is so much greater that polythene is a better economic proposition. It was thought that the impervious nature of polythene might result in undesirable effects on the crop, but no trouble occurred and polythene is now used exclusively. The necessity for complete darkness during the prescribed number of hours cannot be over-emphasized. A hole, $\frac{1}{16}$ in. in diameter on the top part of the cover, will admit enough light to effect bud initiation and development of plants within a radius of several feet. This example serves to show very clearly that controls must be very accurate and complete if the benefits of precision growing are to be obtained in full. A crop grown by such techniques is shown in Plate III.

Another factor of major importance is that of temperature. With the majority of varieties, the optimum temperature to obtain the maximum growth and development rate is a minimum of 60°F at night and this was the temperature used throughout. In considering the possibility of growing year round chrysanthemums, the ability to maintain this temperature must be carefully checked.

Spacing

The amount of space allowed to each flowering stem has a considerable effect on the economics of the crop. Thus a small change of from 5 × 5 in. to 5 × 6 in. reduces the plant population by $\frac{1}{6}$ while practically all costs apart from that of rooted cuttings, remains at the same level. This in turn means a reduction in the number of blooms or stems produced per sq. yd but, as mentioned under spacing experiments at Stockbridge House, extra space usually means improved quality. In our experiments the plants were spaced at 5 × 5 in. for spring and summer crops when the light is good and 5 × 6 in. for those maturing in December. These spacings proved satisfactory and are standard on commercial holdings.

Conclusion

From this general description of the work being done on chrysanthemums it is obvious that the crop holds an important place in the experimental programme. Many of the results obtained so far are of direct benefit to the grower and this is made abundantly clear by the great interest shown by growers in these experiments and observation studies when visiting Stations on Open Days.

PROGRESS IN COLD GLASSHOUSE CROPPING

F. G. Smith, *Stockbridge House Experimental Horticulture Station*

The term "cold glasshouse" is suspect, for it is the function of a glasshouse to be warm, in any case in relation to outside temperatures, but the term "unheated glasshouse" is a little clumsy in a title and the term "Dutch light structure" no longer of necessity conveys the impression of unheated growing conditions, for new forms of unheated glass are being developed, and in the East Riding of Yorkshire in an area where unheated Dutch light structures were once predominant, no less than 60 per cent have heating systems of one kind or another today.

This story begins in the early 1950's. At that time, horticulture in the East Riding of Yorkshire as elsewhere, was emerging from war-time conditions and restrictions, and most structures were unheated of necessity, as well as by design.

The cropping sequence for an unheated Dutch light structure is a simple matter. Lettuce during the winter and early spring months, to be followed during the summer months by tomatoes. By tradition, lettuce was regarded as the main crop; the sheet anchor which gave the grower his livelihood. The tomato crop paid the wages and kept the staff together during the summer months with little hope of more than marginal profits, except of course under war-time conditions which probably opened up to growers the possibilities of the tomato crop. Facilities for soil sterilization where they were not otherwise available were provided by the County Agricultural Committees. Nevertheless, it was the lettuce crop which usually received prior consideration in the cold glasshouse.

As Europe, and particularly Holland, got back into her stride in the post-war years, there was evidence of increasing competition from imported lettuce, and growers realized that tomato crops in unheated structures would have to be more than the "pot boilers" they had been before the war. It was against this background that the work of Stockbridge House Experimental Horticulture Station, relative to unheated Dutch light structures, started in the early 1950's, although it was probably the middle of the decade before we had got ourselves fully orientated in respect of this work.

It soon became clear from our early records that the total yield of our tomato crops was very much affected by the date when the crop was planted. In those days, lettuce was planted in the unheated structures at the turn of the year, partly because it was considered that under our soil conditions losses due to *Botrytis* could be heavy if it was planted earlier, and partly because there seemed little point in putting out plants under the poor winter light conditions experienced at Stockbridge House. This late planting usually meant that the lettuce was not cut until the very end of April, and if late varieties such as Northern Queen and Attractie were planted, the crop could hold on until towards the middle of May. Consequently, tomatoes were planted from the middle of May onwards and yields sometimes no greater than 24 tons to the acre were achieved. Such yields were considered to be about the national average at that time. However, with earlier planting and other conditions being favourable, yields of over 30 tons to the acre were obtained from some houses.

In 1955 it was decided to put down an experiment to investigate the effect of planting date on the tomato crop in an unheated Dutch light structure. The experiment was repeated in 1956 in a slightly modified form. The results of these two experiments were published in *Experimental Horticulture No. 7*. They showed that, for each week's delay in planting after the beginning of May, there was a loss of about 10 per cent of the total marketable yield from the crop, and even earlier planting had substantial effects on early yield (crop picked before 31 August) but without substantially affecting the total yield.

Having thus established the importance of early planting for tomatoes in unheated Dutch light structures, the next stage was to discover how to free the structures from the previous lettuce crop to permit the tomatoes to be planted at the most profitable time. We were helped here by the development, in the early 1950's by Messrs. Tozer of Cobham, of the lettuce variety May Princess,

which proved to be ten days earlier than May Queen the standard variety then being grown. At the same time it was decided to embark upon lettuce planting date experiments and also to investigate the effect of propagation techniques on time of maturity.

The lettuce seed for this crop is normally sown in double span Dutch light frames, making sowings during the first half of October. From such a sowing plants were put out in November, December, January and February, at approximately monthly intervals. Here again some surprising results were obtained. Contrary to what had been anticipated, lettuce planted in November and December suffered far fewer losses from *Botrytis* than those planted in January and February, but this turned out to be not so much the effect of time of planting as of the age of the plants which were put out. In this experiment all plants were taken from the same seed bed. However, November/December plantings did mature a week to ten days earlier than the January/February plantings, and this, combined with the gain from using the early variety May Princess, allowed us to have lettuce crops maturing in our unheated structures by the middle of April, and such crops could be cleared to permit tomatoes to be planted before the end of the month.

Although May Princess was the first of the larger headed lettuce to give us early maturity under cold glass, in more recent years a whole range of varieties, mainly from Holland, have become available, some of them earlier than May Princess and probably of better quality. There is also some indication, from preliminary investigations at Stockbridge House, that even in cold houses CO_2 may be used to speed up the maturity of lettuce, but since CO_2 works most efficiently at high temperatures, its use in cold houses may be confined to the later stages of the crop during a period when high temperatures from sun heat may be achieved in unheated glasshouses. At Stockbridge House work has started, in conjunction with the Glasshouse Crops Research Institute, on the breeding of lettuce varieties which, it is hoped, will mature earlier still, without losing the all important factor of size.

So far, so good; but the revised timing of the lettuce and tomato crops for unheated glasshouses had thrown up new problems. Results had indicated that it was desirable to plant unheated structures with tomatoes before the end of April, but the demand for glasshouse lettuce still remained up to the middle of May or later, and it would certainly glut the market if all lettuce from unheated glasshouses were grown to be cut in the middle of April. True, the lettuce season could be extended with frame crops grown on the alternate cropping system so that some frames were uncovered to permit the lettuce crop to mature in the open, but with the increased cost of labour and glass, which latter is subjected to considerable hazards in covering frames, the use of Dutch lights on the flat was becoming less attractive, as was the practice of moving the roof lights from one structure to another. At this stage it was hoped that mobile glasshouses would provide a solution to the problem, and in fact they do, but unfortunately the cost of mobiles has never quite reached the level which makes them universally attractive, the grower usually being in favour of using his capital to cover a larger area with static glass then to pay for the several advantages of mobility. Nevertheless, the unheated mobile glasshouses at Stockbridge House have been used to extend the lettuce season with crops that start their life under glass and are uncovered to mature in the open. The house is then moved to an

alternate site to establish a crop of tomatoes at the most critical planting date. As more and more Dutch light structures are heated, there are signs of renewed interest in this technique.

Another problem arose from the fact that there is little time to carry out soil sterilization between the tomato crop finishing at the end of October and the house being required for lettuce planting in November. Even though a quick steam sterilization could be carried out with a steaming plough, there must follow some delay before the lettuce is planted, and some of the chemical sterilants, particularly metham sodium, are very slow in being released from the soil at this time of the year. This problem still remains but various methods of overcoming it are being examined. Carbon bisulphide is released from the soil fairly rapidly and, where potato root eelworm is the chief soil-borne trouble, it may be injected following the lettuce crop although it is a busy time of the year to undertake this operation. If potato root eelworm is not a problem there is the possibility of getting over other soil-borne tomato troubles by the use of disease resistant rootstocks.

Work is now in hand at Stockbridge House to compare the value of using disease resistant rootstocks in conjunction with various soil sterilants. In previous work, comparing steam sterilization with different soil fumigants but with the tomato plants on their own roots, the conclusion was reached that steam sterilization and D.D., given in alternate years, was the most economical way of maintaining satisfactory soil conditions for the tomato crop when potato root eelworm contributed to the soil-borne pest and disease complex. (See *Experimental Horticulture*, *No. 8*, pp. 27–37.) Since then, new chemical sterilants have become available, the efficiency of which is being tested in current experiments. It should not be forgotten that the mobile glasshouse can also help solve the problem of finding time to fit in soil treatment since it can be carried out before the site is covered.

More and more growers in the East Riding are at the present time putting heat into their glasshouses where none had previously been used. By this means the growing season for lettuce is shortened and that for the tomatoes extended; soil sterilization by chemicals is made possible at times of the year when it would not be possible in unheated houses; but the use of heat is part of another story which is not covered by the title to this paper.

Other than planting date, a factor which has been found to have very profound influence on the yield of early fruit from an unheated tomato house, is the quality of the plant. Traditional methods of propagating tomato plants have been used in the East Riding which allow economies to be made in the use of heated propagating space. These methods produce tomato plants in boxes (usually a Dutch seed tray, 25 to a tray) to be planted out in the fruiting quarters. There is abundant evidence, from work done at John Innes and elsewhere, of the adverse effects of poor propagation techniques on the cropping of tomatoes in heated houses. Work at Efford and at Stockbridge House showed that poor propagation techniques had the same effects on tomatoes planted in unheated structures. The adverse effect was chiefly on early yield.

Although the first fruit of tomatoes from unheated Dutch light structures seldom reaches the market before the beginning of July, the seasonal price structure from then on is still in favour of early fruit. Tomato prices usually reach their lowest level in early September. Having shown that early yields can

be improved by early planting and good propagation techniques, it was decided to test varieties to see which of them gave the earliest yield. Of the nine varieties grown in an unheated glasshouse trial, the variety Ailsa Craig has consistently been the first or second placed for earliness, being beaten by only one year in three by the variety Eurocross A. Surprisingly, the variety Moneymaker, which has long enjoyed a reputation for earliness, has given some of the lowest yields of early fruit. It is perhaps fortuitous that Ailsa Craig has also consistently given the highest yields of Grade I fruit as judged by normal grading standards. More recently, the fruit of its non green-back form Craigella and that of the new Dutch variety Ouden Dam from unheated glasshouses received special comment in commercial tasting trials in which these varieties have been compared with produce from Holland.

What of the future for "cold glass" ? Low priced structures of improved design are becoming available. These are moving away from the Dutch light as a glazing unit, although using large-sized glass with narrow glazing spars thereby offering less obstruction to light entering the house. The structures are also higher, providing better air circulation for the tomato crop and improved scope for mechanical cultivation, for which there is still room for development particularly in unheated glasshouses, which must remain geared to low cost production. For winter lettuce production, structures should be orientated E–W and should be no wider than will permit low angled winter sunshine passing through the south side of the house to reach the north side at soil level. More importance must be attached to the airtightness of the unheated structure to permit the efficient use of CO_2 and to retain as much as possible of the sun's heat. More work needs to be done relative to the setting of tomatoes in "cold" houses, whether by management at the beginning of the season or by mechanical means during inclement weather later in the growing season. For the lettuce crop, one can look forward to still further improvement in varieties, both in earliness, size and quality.

As costs of fuel are continuing to rise, competition from heated glass will probably decrease in future.

Short Notes on Other Experimental Work

GOOD HUSBANDRY AND WILD OAT CONTROL

The common wild oat *Avena fatua* has considerably increased its range and numbers in many arable districts during the last two decades. Many suggestions have been put forward to explain this increase, but important factors are the increasing proportion of cereals now being grown, the wide use of the combine harvester and earlier drilling of spring corn.

In addition, the wild oat itself has two peculiarities which enable it to compete successfully with cereal crops. These are the ability of its seeds to remain dormant in the soil for a considerable time until climatic and soil conditions are favourable for germination, and the short growing season that it needs to ripen and shed seed successfully.

In areas where a wide variety of crops can be grown wild oats need not be a serious problem. However, they assume greater importance where soil type and economic conditions restrict the range of crops to wheat, barley, oats or beans. The possibility of chemical control of wild oats has only arisen in the last few years and has not been included in the programme of work on wild oat control undertaken at Boxworth E.H.F.

This programme has been devoted to two aspects of the wild oat problem. The first experiment was intended to obtain some basic information on how long wild oat seeds remain viable in undisturbed soil. The results, already published in *Experimental Husbandry No. 9* (pp. 10–13) showed that wild oat seeds were capable of growing after being buried under a ley for as long as seven or eight years. Many seeds germinated after four years under grass, and the numbers only started dropping after the sixth year in ley. The writer concluded that a field infested with wild oats must be down to grass for eight or nine years before it can be considered free from dormant seeds.

The trial provided valuable information on the question of dormancy, and emphasized two important husbandry points. The first, that short leys were of little value in reducing serious infestations, but long leys may be helpful if they can be justified on other grounds; secondly, that the common wild oat has a definite season of germination in the spring, and that, once this period has passed, further cultivation of the soil will not induce any more seeds to germinate. It follows from this that the traditional bare fallow practised in many heavy land arable districts as a way of controlling weeds of various kinds, is ineffective against wild oats. The trial therefore gave little positive help to the heavy land arable farmer, with his limited range of crops, unless he was prepared to consider a ley farming policy.

Therefore a second trial was started, with the object of testing certain husbandry techniques which might help to control the increase of the wild oat under conditions of continuous corn growing.

Two features of the wild oat dictated the choice of treatments. Dormancy in wild oat seeds is mainly brought about by the exclusion of air from the seed by the seed coat. Until the seedcoat is ruptured or broken by bacterial or mechanical action the seed will not germinate. The other was the fact that the common wild oat germinates mainly in the spring with peak germination occurring at the end of March and tailing off by the middle of April. A small proportion of wild oat

seeds also germinate in the autumn. It was felt that the techniques should embrace anything that could be done to damage the seedcoat and stimulate the germination of wild oat seeds at a time when the land was unoccupied by a crop and the subsequent flush of seedlings could be killed by normal cultivations.

The final selection of treatments included straw burning, stubble ploughing or rotary cultivation to stimulate germination in the autumn, when the seedlings could be killed by cross-ploughing in late November or early December. In addition, a delayed spring drilling in late April or early May was planned to take advantage of the late March peak. This was compared with drilling at the normal time as soon as the land became workable in the spring round mid-March.

The trial site was on chalky boulder clay and sown to spring barley each year. A late maturing variety, Proctor, was sown at the normal time, and an earlier one, Rika, at the late drilling so that both crops could be harvested together.

Records of yields were kept. Wild oat seedlings were counted in the autumn, in the spring just before drilling, and also at harvest, to provide an estimate of the effectiveness of the various treatments.

The chosen site did not carry a heavy infestation of wild oats when the trial started in 1957. Harvest counts averaged one wild oat per two square yards. However, numbers built up steadily on the early sowings and the table shows how they have increased over the last seven years.

Wild oats per square yard at harvest

Treatment	*1957*	*1958*	*1959*	*1960*	*1961*	*1962*	*1963*
Early sown	0·5	1·62	1·15	1·95	5·06	38·9	39·6
Late sown	0·07	0·06	0·02	0·03	0·03	0·03	0·08

Wet springs occurred in 1959 and 1963 and early drilling was not possible. Many wild oats germinated before the seedbed was worked down, consequently they were killed and the seasonal build-up, as measured by the harvest count, was either negative as in 1959 or very small as in 1963.

Late sowing cut the numbers of wild oats by 50 per cent in the first year. Numbers fell slowly during the next two years and have remained at a low level ever since. There is a suggestion that they have increased slightly recently. The reason for this increase may be either the selection through continual late drilling of a new race of late germinating wild oats, or as seems more likely, the practical impossibility of preventing the spread of seeds from the heavily infested early drilled plots alongside. This inference is given weight by the fact that the field surrounding the trial has always been drilled late and no wild oats appear except near the trial area.

The second table shows the difference in yield between the early and late sowings.

Cwt per acre (at 85 per cent D.M.)

Treatment	*1957*	*1958*	*1959*	*1960*	*1961*	*1962*	*1963*
Early sown	10·5	28·4	39·0	40·5	26·7	37·0	24·1
Late sown	7·5	24·1	35·1	31·5	28·0	37·8	29·4
Difference	−3·0	−4·3	−3·9	−9·0	+1·3	+0·8	+5·3

In the early years of the trial the difference was always in favour of the early sowing, as might be expected, but recently, as the numbers of wild oats increased, the yields of early sown corn have dropped compared with late drilling. The difference recorded in 1961 is partly due to some necking which took place in the early sown plots.

Straw burning and stubble cultivations have not been effective in reducing wild oat numbers since the population has increased steadily year by year. Autumn counts have always given the impression that many wild oat seeds can be induced to germinate in the autumn but it is clear from the harvest counts that many more are buried in the soil and over winter successfully.

The rate of increase has been slowest on the plots which have not had their stubble ploughed until late autumn and the suggestion has been made that many seeds lying on the surface of the soil are in fact eaten by birds and small rodents. A small observation is being carried out at present to ascertain whether or not this is the case.

Ploughing or rotary cultivation of the stubble increased the number of wild oats chitting in September and October but they also had the same effect in the spring. Unfortunately, because of the low initial infestation, it is not possible to gauge their value as wild oat killers when combined with late drilling. It seems reasonable to suppose, however, that their success in inducing germination is one which can be exploited to the full when coupled with timely spring cultivations and delayed drilling.

Late drilling is not a practice which can be recommended for very light soils, or where quality of malting barley is important; but if it is used under conditions of high wild oat infestations on heavy soils then the loss in yield from late drilling may be negligible compared with the loss caused by the presence of wild oats in barley drilled at the normal time.

J. E. Whybrew

UNDERSOWING SPRING CEREALS

The way in which a ley is established will affect both the cover crop, if any, and the production of herbage. The ley is usually considered more important than the cover crop and both the seed rate of the corn and the level of nitrogenous fertilizer are often lowered to reduce competition with the small seeds. Recent experiments at Rosemaund and High Mowthorpe have investigated these practices.

At Rosemaund, spring barley was used for two years and spring wheat for seven years to find the best combination from the point of view of both cereal and ley production of early or late undersowing, early or late nitrogen application and cereal seed rate. The experiments at High Mowthorpe were all done with spring barley and were mainly concerned with the effect of the variations in the seed rate of different ley mixtures on the yield of the barley, when both were sown on the same day. At both farms it was found that undersowing a corn crop at the time the corn was drilled, reduced the yield of corn by 1–2 cwt per acre. At Rosemaund it was possible to broadcast seeds after the corn had come up, at the brairding stage; this reduced the competition and the yield from such plots

equalled that from plots with no undersown grass. At High Mowthorpe it was found that a good take of small seeds could not be guaranteed unless they were broadcast at the time of drilling the corn, so the late undersowing treatment was omitted after the first year.

At Rosemaund the yield of corn increased for each increase in cereal seed rate but the increment was insufficient to justify the use of more seed than 110–140 lb per acre of spring barley or 190–200 lb per acre of spring wheat. The loss of yield due to undersowing can be reduced by the use of nitrogen. All the later trials at High Mowthorpe used some nitrogen and with 60 units the competitive effects of undersowing were reduced. At Rosemaund the top dressing never exceeded 31 units of nitrogen which sufficed to restore the yield, especially when the nitrogen was broadcast on the cereal seed bed.

At Rosemaund doubling the herbage seed rate in 1955 had no effect on the yield of a cover crop of spring wheat. Thereafter the trials there used a Cockle Park type mixture at 24 lb per acre. At High Mowthorpe, however, the competitive effect of undersowing was increased when the seed rate of the small seeds was raised. A comparison of herbage species has shown that the more vigorous types, such as red clover or Italian rye-grass, cause the greater reduction in yield.

The effect of these various treatments on the yield of herbage in later years has never been very marked, usually 5–10 per cent, nor has the highest yield of hay followed the lowest cereal seed rate. At Rosemaund the yield of herbage was slightly better following undersowing at the time the corn was drilled and where no top dressing was given. Heavy use of nitrogen in the undersown barley crop at High Mowthorpe in 1962, did not affect the establishment of the small seeds.

The trials suggest that the cover crop should be drilled in clean ground as early as possible; the normal seed rate should be used for spring barley, but a slightly reduced rate for spring wheat, and a nitrogen dressing given at the normal rate in the seed bed. Where possible the seeds should be broadcast after the cover crop is established, but where this may result in a poor take they must be sown at the time of drilling the corn. In these circumstances the nitrogen should be maintained at a high level to reduce the competitive effect.

A. L. Francis

DIRECT AND RESIDUAL EFFECTS OF POTASSIUM FERTILIZERS ON YIELDS OF ARABLE CROPS

A long term experiment to test the direct and residual effects of potassium fertilizers on yields of arable crops has now been in progress on five Husbandry Farms for a sufficient length of time to enable the preliminary results to be assessed.

The Husbandry Farms on which this experiment is located are Trawscoed (silty loam on Silurian shales), Boxworth (silty clay loam on chalky boulder clay), Gleadthorpe (loamy sand on Bunter pebble beds), High Mowthorpe (silty loam over chalk) and Bridget's (very fine sandy loam over chalk).

The potassium was supplied as muriate of potash at High Mowthorpe and as sulphate of potash at the other farms. The treatments were tested on a four course rotation at each farm. Main-crop potatoes and spring barley were grown

on all the farms, but the third crop in the rotation differed on different farms being swedes at Trawscoed, Gleadthorpe, and High Mowthorpe, mangolds at Boxworth and kale at Bridget's. The fourth crop in the rotation was a clover ley at Trawscoed and Gleadthorpe, peas or beans at Boxworth, oats and tares at High Mowthorpe and spring wheat at Bridget's.

At Boxworth the yields of the control plots which did not receive potassium remained satisfactory, and little response to potassium was observed. At the other farms, control yields tended to be low, and appreciable responses to potassium were obtained for some crops. At these four farms the highest annual dressing of potassium gave a large increase in yield of potatoes and a relatively smaller increase in yield of barley. Large responses to annual applications of potassium were obtained on swedes at Trawscoed and Gleadthorpe, and smaller responses on kale at Bridget's. The clover ley at Gleadthorpe and the spring wheat at Bridget's also showed appreciable responses to annual applications.

Residual effects of three-yearly potassium dressings were observed one and two years after application. Except at Boxworth these residual effects were appreciable at all farms for potatoes and barley, and for the other crops already referred to above which gave appreciable responses to annual applications of potassium. There was some evidence that similar residual effects, relative to the response to the equivalent annual dressing, were being obtained at Boxworth, but because these responses were small, they could not be so accurately assessed as at the other Farms.

The results of the experiment are in fair agreement with the hypothesis that the equivalents of residues are one-half in the first year after application and one-quarter in the second year, except that for potatoes the effects of three-yearly dressings are smaller than this.

Optimal dressings for cereals are small, and hence cereals can, to a large extent, obtain their needs from residues of higher dressings applied to responsive crops such as potatoes and swedes.

C. W. R. Smith

POTATO SEED PRODUCTION

The production of high grade seed potatoes is becoming an increasingly important enterprise on many farms in the upland areas of northern England. High Mowthorpe Experimental Husbandry Farm, on the Yorkshire Wolds, is in a seed producing area and both Stock Seed and Grade A seed Majestic are produced on the Farm.

To obtain the most profitable return from seed production, the grower needs to employ a combination of management factors that will give a high total yield containing the maximum proportion of seed size tubers of high quality. The requirements for seed growing therefore differ from those for ware production, and a series of experiments have been conducted in which a variety of factors have been studied to assess their effect on the yield of a crop grown for seed.

The potatoes at High Mowthorpe are used as a break crop from cereal growing and are usually preceded by three years of corn. All the trials have been conducted on the variety Majestic, and were riddled to give a seed size of $1\frac{1}{4}$–$2\frac{1}{4}$ in. and ware of $2\frac{1}{4}$ in. and over.

Left:
Disc-seeder working in wheat stubble

Right:
Slit-seeder working in killed sward

Reduced cultivations for cereals

Calves reared outdoors from birth

PLATE I

BOXWORTH EXPERIMENTAL HUSBANDRY FARM

Wild oats in seventh successive barley crop (1963) after early sowing (*left*) and delayed sowing (*right*)

LEE VALLEY EXPERIMENTAL HORTICULTURE STATION

Tomatoes growing on treated straw bales

PLATE II

LEE VALLEY EXPERIMENTAL HORTICULTURE STATION

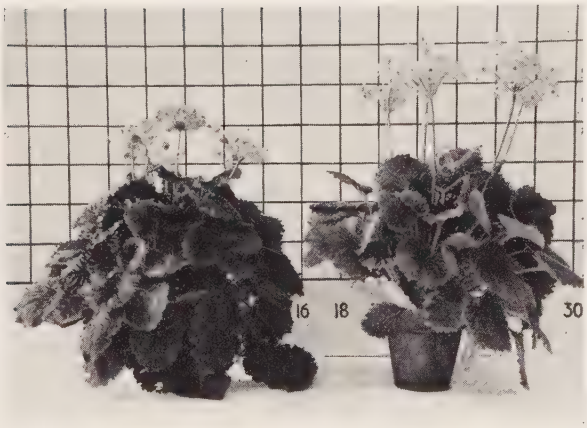
Illumination of antirrhinum seedlings for flower production under glass. In foreground, with mercury vapour lamps; at rear, with tungsten filament lamps

FAIRFIELD EXPERIMENTAL HORTICULTURE STATION

Controlled flowering of chrysanthemums, Variety in flower is Indianapolis White. In background, Vanguard. The plants are being grown in a nutritional experiment

PLATE III

Control of blackcurrant leafspot. Sprayed bushes on left: unsprayed control bushes on right defoliated



Primula malacoides

Left:

Unshaded control plant

Right:

Plant from a shaded treatment. Variety Fire Globe

Horseradish growing: Stocks from Yugoslavia (*left*) Sweden (*centre*) and Cheshire (*right*). Thickened roots are the marketable crop. Thin roots are cuttings for replanting

Manuring

The first series of trials examined the fertilizer requirements of the crop. The soils at High Mowthorpe are classified as medium-high for phosphate and low or very low for potash, and it was therefore not surprising that up to 360 units of K_2O/acre gave an economic response in total yield. High levels of potash tended to increase the ware in the crop and reduce the seed fraction whereas phosphate encouraged seed production. The optimum level of plant nutrients for seed production proved to be 100 units N; 140 units P_2O_5 and 240 units K_2O/acre. This applied when the fertilizer was spread over the ridges and no farmyard manure given. In the presence of FYM the supply of inorganics should be reduced by approximately 30 units N, 40 units P_2O_5 and 75 units K_2O per 10 tons of dung applied.

Planting Date and Chitting

For maximum yield it is important that planting should take place as soon as the soil begins to warm up enough to allow growth to start. Planting earlier than this, so that the seed tubers lie dormant in the soil for a period before starting into growth, has reduced yields. Delaying planting for two or three weeks after the optimum date has seriously reduced the yield of ware, and any increase in the amount of seed has been too small to compensate for this loss.

Chitting the seed compensates for late planting to a large extent, and chitted seed planted late has generally given yields of both seed and ware equally as good as bagged seed planted at the normal date. At the normal planting date in good growing seasons chitting has only resulted in an increase of $\frac{3}{4}$ ton per acre, but larger responses have been recorded when planting was delayed by bad weather, or growth retarded by either adverse weather conditions or disease. The bulk of the increase in yield due to chitting occurs in the ware fraction, without reducing the yield of seed, the practice is therefore profitable for the seed grower as well as for the ware producer.

Spacing and Size of Seed

Seed rate in the potato crop is a product of the size of seed used and the spacing of the seed within the row. The effect of both factors has been examined by comparing seed size tubers ($1\frac{1}{4} \times 2\frac{1}{4}$ in.) and small ware ($2\frac{1}{4} \times 2\frac{1}{2}$ in.) set at 9 and 15 in. on 28 in. rows. Using small ware at the close spacing gave the best total yield and increased the yield of seed by over 1 ton per acre compared to other treatments, but in most circumstances would be uneconomic because of the high seed rate of 4 tons/acre that is required. With normal seed size sets planting at 9 in. rather than 12 or 15 in. maintained the yield of ware and increased the yield of seed by over 1 ton per acre. The economics of planting close will depend on the relative prices of the seed to be set and the resulting crop; with inexpensive seed 9 in. spacing will pay but with high priced seed a wider spacing is advisable.

Burning Off

Early destruction of the haulm is advisable in many seed producing areas to prevent late aphid spread of virus disease. Comparison of the yield of crops burnt off with acid in mid-August with that of crops allowed to die back

normally showed that burning off had little effect on the yield of seed but reduced the yield of ware, particularly with late planting. Chitting went some way towards reducing this loss of yield.

Future Work

The programme of experiments is being continued at High Mowthorpe and future work will concentrate on the effects of seed size and spacing, and the use of herbicides which may lead to the adoption of the newly developed "bedding" techniques for seed production. Observation studies are being organized to learn more of the latest chitting techniques; these can affect the number of shoots produced per tuber and may be useful to the seed grower to enable him to increase the proportion of seed sized tubers in his crop.

R. B. Mair

SYSTEMS OF SPRAYING FOR POTATO BLIGHT CONTROL

Trials at Terrington E.H.F. from 1948–53 were reported in *Plant Pathology* by Large, Taylor, Storey and Yule in June, 1954, who summarized their findings as follows:

> "The first six years of the trials at Terrington, taken in conjunction with past records and observations made in the course of the blight forecasting survey in 1950–53, indicate that in the important potato-growing area for King Edward, three years in ten may be expected to be blight years, with the disease reaching the 75 per cent stage by mid-August, and with a probable gain from efficient spraying of 2–3 tons per acre on the heavier crops. In addition, there may be expected to be two years out of the ten in which blight reaches the 75 per cent stage by the end of August, with a probable net gain from spraying of about 1 ton per acre, and another two years in which the disease will not reach the 75 per cent stage until mid-September and any possible small gain from spraying will be lost by wheel damage. Finally, the remaining three years may be expected to be ones in which there is no blight at all, and in which there will be substantial loss from spraying, due not only to wheel damage, but in some cases also to phytotoxic effects, especially where there is heavy aphid attack. The gain from spraying Majestic in blight years may be expected to be less than on King Edward, for, as in 1953, blight on Majestic frequently reaches the 75 per cent stage a week or a fortnight later than it does on King Edward.
>
> "Consideration suggests ways in which the losses in no-blight years could be reduced or avoided, and by which applications in blight years could be saved or timed more effectively. First, applications in June appear unnecessary, except in a very few exceptional years such as 1953, when the outbreak was definitely forecast for early July. In general the optimum time for a precautionary first spraying in this area is about the end of the first week of July, when, incidentally, the machines can get through the haulm without causing any appreciable damage. Next, with the precautionary spraying applied at this time, the second spraying could be deferred until

outbreaks have been seen or forecasted for the district. Thus in no-blight years the second application would not be given at all and there would be a saving both of the cost of the application and of the loss of crop caused by it. In blight years the second application would be in time and it could be followed by a third to maintain the protection for as long as possible, if it were seen that rain was washing the deposits off the haulm.

"With the development of potato blight forecasting in this country, some growers in the district may be able to save even the first precautionary spraying in no-blight years".

By 1960 the forecasting of blight had developed considerably and all potato growers in the Eastern Region were receiving postcard warnings based on data from R.A.F. and other meteorological stations and from recording thermo-hygrographs erected for the purpose in the potato growing area. For the years 1958–63 these Regional warnings were never sent out too late as judged by experience in the Terrington area and the saving of the precautionary spray has been shown to be possible.

Considerable insight into the planning of blight spraying was derived from a study of three of the treatments in the 1958 trial at Terrington. Sprays of copper oxychloride were applied as follows:

Treatment	Precautionary spray	Blight warning spray	Successional sprays		Total yield
	30 June	11 July	24 July	7 Aug.	tons/acre
A		Control—no sprays			7·6
E	x	x	x	x	9·1
F	x		x	x	7·8
G		x	x	x	10·3

Treatment G, based on the warning, gave the highest yield. Treatment E, which included all the sprays in G and also an extra precautionary spray, gave 1 ton/acre less yield due presumably to wheel damage and copper toxicity. Treatment F, which included the precautionary spray but omitted the warning spray, was hardly better than control. In 1958 the 24 July spray appeared to be of little value as it was applied between two very wet periods (21/22 July and 27/28 July) but the spray on 7 August had time to dry on before further heavy rain fell on 13/14 August. This spray prolonged growth usefully on treatments E and G but not on F, where blight had by that time already killed about 40 per cent of the foliage.

Since 1959 the Terrington trials have been designed to test the hypothesis that spraying firstly on the blight warning and thereafter only after considerable rainfall will give the best yield increase in years when blight is serious and will cause the least expenditure and loss from wheel damage or toxicity in years when blight is slight or extremely late. The rainfall criterion tested has been that 0·5 in. or more of rain should fall in a period of 5 days or less. This, and other treatments, have been compared with a routine system of spraying starting with

a precautionary spray in early July which is followed by further sprays at 10-day intervals. Over the four year period 1959–62 there was one year of severe blight (1960) and one year (1961) when blight was moderately severe. In 1962 the damage from blight was slight and 1959 was a dry year with no blight. The mean yields of King Edward from the three main treatments are shown below:

	Mean number of sprays	Yield of ware tons/acre
Control—no sprays	Nil	8·9
Routine spraying at 10-day intervals	5	8·6
Spraying at blight warning and then after 0·5 in. rain (0·6 in. in 1960)	3	9·8

The yield from routine spraying is perhaps abnormally depressed by a very low yield in 1962 when the first spray, on July 10, caused severe copper toxicity. Even allowing for this, it is clear that wheel damage and copper toxicity resulting from frequent spraying are likely, over a run of years, to offset the increase in yield obtained in bad blight years. On the other hand, when the first spray was applied on receipt of the blight warning (mean date 22 July) and subsequent sprays followed periods of rain, only three sprays were applied each year, two fewer than the routine treatment, and the mean yield of ware was almost 1 ton/acre higher than control. This mean gain includes slight reductions in yield in 1959 and 1962 but these are offset by gains of 2 tons of ware per acre in 1960 and 1961. In the Terrington area this technique is clearly superior to routine spraying at 10-day intervals; it costs less and gives an increase in yield.

Somewhat comparable trials were started at Bridget's Farm, in 1960, to assess the need to maintain a continuous deposit of active fungicide on the foliage of Majestic potatoes throughout the period when blight may be infective. Two treatments have been used to obtain this continuous cover. In the first, a spray is applied as soon as the blight warning for the area is issued. From then onwards the crop is sprayed at fortnightly intervals or more frequently if a total of 0·75 in. of rain has fallen since the last spray or if over 0·4 in. has fallen during 24 hours. The second treatment is as the first but also includes an "insurance" spray applied on 5 July which will normally precede the blight warning. In these two treatments spraying ceases during the third week in August. Over three years these treatments have received an average of 4·6 and 5·6 sprays a year. They are compared with an unsprayed control and also with a routine spraying system consisting of three sprays applied at three-weekly intervals on 5 July, 26 July and 16 August. In 1960 copper oxychloride only was used. In 1961 and 1962 this material was compared with maneb.

1960 was a year of severe blight at Bridget's, as at Terrington, and all spray treatments produced yield increases of over 3 tons per acre, with the "continuous cover" slightly superior to routine spraying. In 1961 blight was less serious and no spray treatment was significantly better than any other or than control. In 1962, when blight appeared late and did not develop rapidly, all spray treatments, apart from routine maneb, produced lower yields than control. In these two years maneb gave a somewhat better result than copper oxychloride.

The Bridget's trial has shown a consistently better control of foliage blight by more frequent spraying but these differences have not been reflected in the yields. If yield is to be taken as the criterion, it does not appear to be necessary, in that area, to maintain the continuous deposit of fungicide on the leaves of Majestic potatoes.

One point emerges quite clearly from the trials on these two farms which are situated in markedly differing areas of England. The greatest economic advantage will not be obtained by very frequent spraying of the potato crop regardless of weather conditions. In Hampshire, adequate control on the less susceptible Majestics may require relatively few sprays, even in severe blight years. In the Fens, where blight-susceptible King Edwards are widely grown, carefully timed sprays have produced the best results. Evidence is accumulating that, if the spray programme can be closely linked to weather conditions, it should be possible to obtain the optimum economic response from relatively few carefully timed sprays.

F. E. Shotton

WEED CONTROL IN POTATOES BY CULTIVATIONS OR BY CHEMICALS

Weed control in cereals by the use of selective herbicides is now standard practice and considerable progress is being made with the application of this technique to sugar beet. With potatoes the use of herbicides is less developed. Moreover, over a considerable part of the main potato-growing area, the problem in potatoes differs from that in cereals and even in sugar beet. Apart from the fact that in some areas perennial grasses and late developing weeds, such as fathen, may present special problems, it is usually possible to control weeds in the potato crop by mechanical means with occasionally a small amount of hand work. In these circumstances it might be expected that the advantage from using herbicides would be less than in cereals, for the basis of comparisons will normally be between the yield of a crop kept clean by cultivating and that of one kept clean by herbicides. Why should there, in fact, be any difference at all?

As long ago as 1939 Rothamsted trials showed that hoeing had no advantage over hand pulling of the seedling weeds, though both treatments gave higher yields than unweeded plots. Further work in 1942 and 1943 showed that an increase in the number of cultivations might lead to a reduction in the yield of potatoes.* The implication of these results is that, whereas it is essential to remove weeds from potatoes, the direct effect of the cultivations employed to do so might be detrimental to the growth of the crop.

From 1961–63 trials in silty loam at Terrington have compared the yield of King Edward potatoes kept clean by normal inter-row cultivations with others which, after the ridges were split following hand planting, received no further cultivations but were sprayed with herbicide just as the potatoes started to emerge. The sprayed plots were not moulded up. Various herbicides have been tested and on the average of the 3 years' trials the best two chemical treatments have given 2·1 tons/acre more total yield than normally cultivated plots, an increase of 17 per cent. In 1963 the same comparison for Arran Pilot showed a gain of 0·8 tons/acre (10 per cent.).

* E. W. Russell. Rep .Rothamst. exp. Sta. for 1949. p.130.

During the same period similar trials on the sandy soil of Gleadthorpe have shown a gain from spraying compared with normal cultivations in 1961 and 1963 which averaged 1·3 tons/acre (11 per cent) when the crop was not irrigated. Under irrigation there was a slight gain in 1961 but a reduced yield from herbicides in 1962 and 1963 with an average loss of 5 per cent over the three years.

One year's experiment at Bridget's showed a gain from the use of one herbicide but a reduction from another material, which caused visible damage to the crop. This emphasizes the fact that the chemicals at present in use are not truly selective and can, under certain conditions, damage the potato crop. This point is being investigated in Weed Research Organisation trials on all three Farms.

Looking back to the results of the Rothamsted trials, it seems reasonable to assume that the gains now recorded from the use of herbicides are in fact a measure of the damage being done by inter-row cultivations on the control plots. Such damage may be either direct, through the disturbance of roots and breaking of haulm, or indirect as a result of greater loss of moisture from cultivated soil. At Gleadthorpe and Terrington an attempt has been made to reduce this damage by modifying the type of cultivations carried out. At Gleadthorpe shallow cultivations with continental type ridging bodies have each year produced better yields than a sequence of normal cultivations which ended with traditional ridging. Under irrigation the low continental ridges produced a better yield than chemical sprays but these two treatments were equally effective over two years when the crop was not irrigated. At Terrington continental ridging bodies gave a yield of King Edward about equal to that obtained from herbicides in 1963. A somewhat similar approach to the problem with Arran Pilot produced a slightly lower yield than normal cultivations.

Further work to determine the best shape of ridge to put up, if herbicides are to be used, is in progress at all three Farms but no clear conclusions on this point can yet be drawn.

F. E. Shotton

CHEMICAL WEED CONTROL IN SWEDES

A number of experiments at High Mowthorpe (Progress Report 1962) have demonstrated that labour-saving techniques can be used with swedes without undue expenditure on machinery. For example, reducing the seed rate from 2 to $\frac{1}{2}$ lb per acre, cut singling times by half. This was achieved with a precision drill as well as an ordinary agitator type drill. Mechanical down-the-row thinners were also tried but with less success.

Reducing the seed rate with the ordinary drill does not eliminate hand work because doubles and weeds have to be removed in the rows. But seed spacing with the precision drill is so accurate that at 8 in. spacing no singling is required, although hand labour may still be required to remove weeds growing between plants. These weeds may prove costly in labour and compete severely with the widely-spaced swede plants. Efficient cultivations obviously reduce weeds but moisture is lost from the seedbed. If a chemical method of weed control can be developed in conjunction with the precision drill then all handwork could be eliminated.

Pre-emergence hormone or residual types of weedkillers are not suitable for a rapidly germinating crop like swedes but contact sprays have been used with

some success in three years' trials. The pre-emergence contact spray, used with the precision drill at 8 in. spacing, gave sufficient weed control in two of the three years for hand labour to be dispensed with.

Spraying was done in conjunction with a stale seed bed technique, in which final cultivations were completed from two weeks to a month before drilling. This method conserved moisture, killed early weeds and allowed further weed seeds in the surface soil to germinate and grow. The swedes were then drilled and the weeds sprayed off within a day or two. This spraying may be done just before drilling if weeds are expected to block the drill.

Diquat was used as the pre-emergence spray in a trial in 1961. This is a plant dessicant which becomes inactive on contacting the soil. At 4 pints per acre in 10 gal of water plus wetting agent it controlled dicotyledonous weeds and no hand labour was required with swedes precision drilled at 8 in. *Agrostis* and *Agropyron* were not controlled by diquat.

Paraquat was used instead of diquat in 1962 as this was expected to give a better control of grass weeds. The trial which was all drilled at 8 in. spacing, compared no spray with spraying on seedbeds prepared two weeks and four weeks before drilling. Some of the sprayed plots were not side-hoed. The spring was dry so that there was little growth of weeds, particularly on the seedbed prepared two weeks before drilling, but spraying was sufficient to control weeds for the season. No late weed growth occurred on the plots which were not side-hoed except for a small amount of annual meadow grass. The results from the two trials are summarized as follows:

Treatment	*Plants per acre*	*Tons per acre*
No spray	27,357	23·8
Sprayed	24,767	24·1

The trial was repeated in 1963 with disappointing results. Seedbed cultivations could not be done efficiently because of wet weather and, although a very good growth of weeds was produced with both early and late seedbeds, there were many weed seeds still to germinate. The weeds were killed by the spray but the passage of the drill through the soil was sufficient to germinate more weeds which had to be removed by hand.

The trials have shown that in a year when seedbeds could be properly prepared weeds could be controlled by a pre-emergence spray in swedes drilled at 8 in. spacing so that no hand work was required. In a very wet year, when cultivations were hampered, spraying reduced but did not eliminate handwork because the disturbance of the soil by the drill germinated further weeds in the row. Further work will be done on this aspect of the problem.

J. Roebuck

MAIZE SILAGE

There has been for many years a fluctuating interest in maize as a potential fodder crop in this country. In the U.S.A. maize or corn silage is very widely grown because it provides a great weight per acre of palatable feed and, if cut when the grain in the cobs is cheesy, dry matter production is at a maximum and good quality silage can be made without paying particular attention to consolidation or control of temperature. However, until the introduction of productive

early hybrid varieties suitable for cool English summers, maize rarely reached the required stage of development and the resulting silage was poor in feeding value and difficult to conserve. Maize is normally sown about the beginning of May and unless May and June are exceptionally warm, early establishment is likely to be slow and weed competition therefore a serious problem. However, the pre-emergence herbicides simazin or atrazine, sprayed at 1–2 lb of the active material immediately after drilling, have been found to control annual weeds effectively until the late summer.

This was certainly the experience at Gleadthorpe in the past three years when simazin at 1 lb/acre active ingredient gave excellent control throughout the season, even in 1962 when the cold summer resulted in a very stunted poorly grown crop. So far as fertilizing is concerned there is evidence that the economic limit to dressings of nitrogen for maize is around 80 units/acre but growth is so affected by temperature and water supply that responses to nitrogen may not be shown. For example, at Bridget's in 1961 no benefit from dressings of nitrogen up to 100 units/acre was found because growth was so much restricted by droughty conditions. Experiments have shown that the optimum plant density is about 35,000 per acre and a seeding of 35 lb/acre is commonly said to be sufficient to achieve this on 28 in. rows. At Gleadthorpe on 28 in. rows, however, seed rates of 28–39 lb/acre, used in 1962 and 1963, resulted in plant populations of only 20,000–22,000/acre although bird damage was negligible. Presumably this is related to the extremely cold soil conditions found in the spring of both these seasons. In the first year, 1961, when conditions were more favourable, the quantities of seed sown were rather low (22–25 lb/acre) giving approximately the same population as in the succeeding years. Bird damage can be a major problem but in three years at Gleadthorpe losses from this cause were small. In the first two seasons black cotton was strung over the area, but in 1963 a carbide gun was enough to discourage birds during the vital period when the young plants first appeared above ground.

The crop was harvested with a double chop forage harvester equipped with row crop attachments and this made an excellent job and left very little cob on the ground. The cut produce was blown into an improvized box of wire netting supported by high tensile wires stretched between the stanchions of a Dutch barn: the box was lined with sisal paper and, after filling, the top was sealed with polythene sheet, weighed down with sleepers.

Although harvesting was deferred until mid-October, the cobs failed to ripen properly to the cheesy stage in all three years, although they came nearest to doing so in 1961. In that year the average weight of green crop (whole crop recorded over weighbridge) was 15 tons per acre, in 1962 barely 5 tons per acre and in 1963 12 tons per acre. These are very disappointing yields considering that negligible bird damage occurred and weeds were well controlled, but admitted by the summers in 1962 and 1963 were exceptionally cold and miserable.

Experience at Bridget's both in 1961 and 1962 was also far from encouraging since, in the first year, growth was poor owing to the dry summer and in 1962 the crop was extremely patchy for reasons not connected with any soil differences: yields in both years were quite uneconomic.

There is little doubt that higher than average summer temperatures are needed for good yields of maize in this country and these conditions were not encountered

in the years under review even at Bridget's in the southern counties, far less in the north of Nottinghamshire.

The results of two years feeding the maize silage at Gleadthorpe can be briefly summerized. The silage was extremely palatable although, at 16 per cent, the dry matter content was rather low owing to the relative immaturity of the crop. When fed with 2 lb of cereal, pig potatoes and straw, 15 month outwintered Friesian steers consumed 70 lb per head per day of the silage and gained weight at just over 1 lb/day. This performance was almost exactly the same as that recorded for a comparable group of cattle fed on silage made from Italian ryegrass (20 per cent dry matter), except that the daily consumption of this silage was about 7 lb less. In the first season 1961, there was enough maize silage to feed 16 steers for a six week experimental period but the crop was so poor in 1962 that there was only sufficient to keep a group of nine beasts for just over three weeks. The digestibility of both silages was determined by feeding trials with sheep. Averaging both years the digestibility of the maize silage was found to be 68 per cent as compared with 71 per cent for the silage made from Italian ryegrass so the two products must be regarded as similar in feeding value.

The conclusion of three years experience is that, although maize produces excellent fodder, the varieties available are unsuited to the climate of the east Midlands as far north as Gleadthorpe. Except in very hot summers well fertilized grass will give better yields with less risk from birds and without the need for special forage harvester attachments.

P. N. Harvey

INTENSIVE REARING OF DAIRY HEIFERS

An attempt is being made on two Experimental Husbandry Farms to discover whether the rearing of heifers on an all-concentrate diet, similar to that used in the production of barley beef, is a good method of producing dairy herd replacements.

The work started with 12 Ayrshire calves at Great House and four Friesians at Boxworth all born in the winter of 1961–62. All the calves were weaned at three to five weeks old and were changed on to the barley concentrate by sixteen weeks old, the Ayrshires being allowed hay until this age and the Friesians getting no hay but being bedded on straw. The barley concentrate was fed to appetite to the Ayrshires to 11 months of age and to the Friesians to 16 months of age, and after this they were fed rations consisting largely of bulk feeds. The health of the Ayrshires was good, but there was recurrent bloat trouble with the Friesians and one heifer died of bloat at four months old.

Ayrshire heifers were served by an Ayrshire bull at their first heat and Friesians were inseminated at their second heat using Aberdeen Angus semen. Seven Ayrshires and two Friesians held to first service, one Ayrshire and one Friesian held to second service and three Ayrshires held to third service, leaving one Ayrshire geld.

At calving the Ayrshires averaged $6\frac{3}{4}$ cwt at 20 months old and the Friesians averaged 8 cwt at 19 months of age. Two Ayrshires and two Friesians needed assistance at calving.

Feed cost per heifer to calving was £63 15*s*. (Ayrshires) and £78 11*s*. (Friesians). Early indications are that first lactation milk yields are likely to be low.

S. C. Meadowcroft

HORSERADISH GROWING AT STOCKBRIDGE HOUSE

Since the Second World War horseradish sauce has become more popular and this has led to an increase in demand for the plant, which is mostly imported from Sweden, Denmark the Rhineland and Jugoslavia. The traditional centre of production in this country was in Cheshire where it was on a small scale. More British growers have taken up cultivation of the crop in recent years.

Home grown roots are available during the dormant season (until March). Their acceptability is judged more by their size and the ease with which they may be cleaned than by essential oil content. Proximity to the factory is an advantage as it enables the roots to arrive in a fresh condition making processing easier.

Horseradish is grown from stecklings (cuttings) and is treated as an annual crop. The marketable produce consists of the original steckling after it has thickened by one season's growth. Stecklings may be prepared in advance of planting and are planted by hand in holes made in ridges, a team of two persons working together. The ridges are usually 2 ft 6 in. apart and the holes are made by hand at intervals of 18 in. at an angle of about 45° to the horizontal. It is desirable for a block of stecklings to point all in one direction which is reversed for the next block, thus making "round trip" cultivations along the direction of the stecklings possible.

Weed control may be greatly eased by an overall spray of simazine (2 lb active material) immediately after planting.

The crop is normally ploughed out in the late autumn and the plants are gathered and shaken free from soil by hand. Every piece of root must be removed from the field. Horseradish is winter hardy and can be harvested at any time until the spring when soil conditions permit, plants normally being lifted throughout the winter to meet the processors' requirements. However, some plants should be lifted in the autumn so that stecklings may be prepared early, allowing them the maximum time to nitiate buds.

Results from Experiments

(i) PROPAGATION MATERIAL. Four distinct stocks have been used at Stockbridge House.

The *Wild English* produces a root which is thin and rough, and prone to the production of both fibrous and thicker lateral roots.

The *Cheshire* has a similar rather rough nature but gives a yield at times comparable with those of the imported stocks. It tends to give comparatively few of the long lateral roots suitable for use as planting material.

The *Jugoslav* stock, though not producing such heavy yields as the Swedish, has a root which is of singularly high quality, being almost free from both lateral roots along the length of the main root and from small fibrous roots. In consequence it has a smooth skin and is easily cleaned.

The *Swedish* stock has, in the Stockbridge trials, proved to be the heaviest yielding. It has a reasonably smooth skin and produces many long lateral roots which provide an abundance of full length propagating material. These three latter stocks are shown in Plate IV.

The essential oil content, analytically difficult to assess, appears to be satisfactory in all four strains.

(ii) STECKLING LENGTH AND SPACING. Virtually the whole of the crop consists of the thickened planted material, only very small additions coming from the thickest of the lateral roots. It follows that yield will be restricted if the stecklings planted are too short. On the other hand, since only one year's growth is permitted, there may be an optimum steckling length, greater lengths not giving higher yields.

At Stockbridge House there was an increase in yield per acre the longer the steckling, up to a length of 14 in. Thereafter, there was no further increase in yield and quality declined with the thinner roots produced.

Spacing trials have given evidence of increased yield per acre as the within-row planting distance is reduced from 15 in. to 9 in. However, an acceptable compromize between the high planting cost and demand on propagating material inherent in the use of a 9 in. spacing, and the desire for high yield, is to use a 12 in. spacing. The further reduction to 9 in. entails using one-third more stecklings to raise the crop by about one-quarter of a ton per acre only, and since the roots are thinner at harvest, there is a general lowering of quality.

(iii) FIELD CULTURE. For ease of cleaning by the processor it is desired to have a root clear of laterals except at its base, and with no multiplicity of crowns at its upper end. In Swedish practice an attempt is made to produce such roots by clearing the soil away from the upper few inches of the steckling a few weeks after planting, rubbing off all exposed roots with sacking or hessian and singling the shoot growths before replacing the soil. This practice has been investigated at Stockbridge House but has given poor results.

Crown thinning and lateral root stripping may give a slightly more acceptable root, but at the expense of a substantial reduction in yield. Both operations have a serious effect on yield, but crown thinning, with the attendant loss of leaf area, can in some years cut the yield by one-third. The two operations together may reduce the final yield by 40 per cent or more. To sacrifice the whole of the crown region by removing it in the packing shed might well prove preferable should the processor insist on roots being free of complicated crowns, a situation which does not yet obtain.

(iv) STORAGE. Horseradish sauce has a relatively short shelf life so the processors require a continuous supply of roots throughout the year.

A trial was therefore carried out to ascertain whether it is possible to extend the season of supply of the home produced crop. Bundles of roots were prepared and placed in trenches, some horizontally and others in an inverted position, and covered with 4 in. of soil. Vertically placed controls were also included. The roots were stored in December and removed for sale in batches, six, seven and nine months later. In spite of the application of "Fusarex" to the bundles of roots (at the rate of 5 oz to a ton of roots) to retard shoot growth, shoots had appeared above ground level by the time of the June lifting, there being less growth from inverted roots than from upright or horizontal roots. Losses from rotting were considerable and not related to storage treatment. It was apparent that, stored in this way, the roots were liable to a certain amount of desiccation which reduced both weights and quality, an effect which might be attributed to the slightly cloddy condition of the soil, which prevented it from packing closely round the bundles.

Roots stored in an inverted position kept best but even with this method the loss by the end of June was about 25 per cent and by late September had reached 50 per cent.

Where it has been tried, no success has been reported from the cold storage of roots. Even accelerated freeze drying at the research factory at Aberdeen proved unsuitable due to the loss of essential oil, and to discolouration. Yields are diminished and quality low if the grower lifts during the growing season.

(v) ERADICATION. It is widely held that a major objection to the growing of horseradish is the difficulty of subsequent eradication. Provided the plants are grown in ridges so that ploughing out can be substantially complete, and the crop is never left in the ground for more than one growing season, thus preventing a deep root run, eradication is not an insuperable problem.

If the ground can be fallowed following horseradish, two rotary cultivations at fortnightly intervals will give a satisfactory control of volunteers in a dry summer, or in a wetter season, an August foliar spray of a mixture of 2, 4—D and 2, 4, 5—T will be effective. A better practice, which enables the land to provide a steady revenue, is to use a following crop of short duration, such as corn on which selective herbicides may be used, or one with which frequent mechanical cultivations are possible. Above all horseradish must be treated as an annual crop.

It is apparent from the work conducted at Cawood that crops of 5 tons per acre can be obtained in this country using existing growing techniques. This compares satisfactorily with the cropping rates reported by our overseas competitors. There appears to be no reason why English growers should not take full advantage of their nearness to the processing factories and supply a large part of the existing marker for horseradish.

M. W. Case

FACTORS AFFECTING CROPPING OF EARLY POTATOES

Some of the factors which may affect the rate of bulking of a particular variety for early lifting are size and source of seed, storage treatment at any time during the period from lifting to planting, method of chitting and treatment at planting.

Size of Seed

Size of seed affects the rate at which a crop bulks up early in the season. Trials carried out at Rosewarne to test the effect on Arran Pilot seed yielded some useful information on this point. Where a constant planting distance of 2 × 1 ft was used, crop yields from two sizes of seed showed that the larger seed (3·4 ounce size) gave a heavier crop than small seed. If it was desired to economize in the use of seed it was better to cut the large seed in two and maintain the same plant population than to plant uncut seed at the increased spacing of 2 × 2 ft. In some circumstances small seed, even when planted at the same rate per acre, is known to be later in bulking than medium seed. The use of very large cut seed has given as good, or nearly as good, results as the use of a similar quantity of uncut large seed.

The planting of whole large seed at normal spacing is likely to be worth while, particularly if home produced seed is used with the object of obtaining early crops. Certainly better results can be expected if the seed is graded and the different grades planted separately, the larger seed giving the earlier crops and the smaller seed crops being left for later liftings. This will largely avoid the mixed crop at various stages of maturity which result from planting a batch of seed of a wide range of sizes. Because of the high cost of seed per acre and the competition between the large plants from such seed, very large seed should be cut before being planted at the usual distance.

Depth of Planting

Depth of planting may also affect the time at which a crop is ready for lifting. Arran Pilot planted at Rosewarne on the surface and covered by 2 in. of soil or planted in shallow furrows 3 in. deep and given a shallow covering of soil, in both cases matured earlier than seed planted deeper and covered by higher ridges. At a planting distance of 2 × 1 ft there has been very little greening of the very shallow planted crop.

Chitting

Chitting of seed is essential for early crops. Although, for various reasons other structures are often recommended, very satisfactory results have been achieved, in trays in a glass chitting house at Rosewarne, of sprouting seed received at the end of November or early December. Some form of heat, such as oil stoves or hot water pipes, is necessary to prevent the temperature falling below 40°F. In mild weather, which may occur even in the shortest days, plenty of ventilation is needed to keep the temperature from rising too high. The same applies more frequently in late February or early March during years when wet weather has prevented planting. Sturdy green sprouts 1–1½ in. long are ideal for some forms of planting but, because of difficulties with weather or storage, in some cases sprouts may be etiolated and several inches long. Lighter crops may be the result if such seed is roughly handled but simple trials have shown that with careful handling it can yield as well or nearly as well as that set up at the same time but with shorter sprouts resulting from more light.

Once Grown Seed and Little Potato

In milder climates once grown local seed has an advantage over that from more northerly areas by producing crops which bulk a few days earlier. However the use of such seed is not without some disadvantages. Some varieties, notably Ulster Premier, it has been observed at Rosewarne, need careful treatment. If the seed crop is planted too soon, harvested too soon or stored at too high a temperature for too long early in the season, the resultant seed and its shoots may be in a very advanced state at planting time. If the very forward shoots are damaged by poor soil conditions or by other means, the resulting crop may be very gappy, the stems may fail to grow and only small tubers may develop from the old sets.

Controlling the storage temperature at about 45°F from lifting to setting up for sprouting, greatly reduces the risk from trouble of this kind. It has been known for a long time that too early planting and lifting of seed crops of some early varieties may be the cause of failures in subsequent crops. Late lifted seed

of Ulster Premier has given better results than early lifted seed from an April planted seed crop. Repeated removal of shoots is said to cause 'little potato' if the seed is planted in soil with a temperature below 50° F. This may well be so in some circumstances, but removal of shoots once or twice in December and January in 1963, from seed lifted in July gave a much better stand of plants than leaving on the first shoots of seed which was later planted in early April.

It has been stated in literature that sprouting tubers in light is a sure means of preventing 'little potato'. But this is not true in every case as some severely affected crops have been produced from seed sprouted in well lit glasshouses and planted out in West Cornwall.

E. G. Ing

GROWING TOMATOES ON TREATED STRAW BALES

At the Lee Valley Experimental Horticulture Station a method of tomato growing is being investigated which offers a new approach to the old problem of controlling the pests and diseases which attack the tomato plant via its roots. One of the most insidious of these is that caused by tomato mosaic virus which not only brings about a loss of yield on many nurseries but also leads to a serious deterioration in fruit quality. Other diseases, such as *Verticillium* which enter the plant through the roots, are controlled by routine soil sterilization but even after steaming the border soil, symptoms of tomato mosaic virus often appear in a matter of weeks, the virus having persisted in infected root debris from the previous crop. Now if virus-free plants could be set out on prepared straw bales, isolated from the soil beneath by wide sheets of polythene, there would be a good chance of growing a crop with a low incidence of virus, provided the structure of the house had also been cleansed and other sources of contamination could be avoided. Such a system of growing would also control the root diseases which normally necessitate regular soil sterilization.

The large quantities of straw (approx. 75 tons per acre) have been shown to give a material increase in the CO_2 level in the glasshouse atmosphere while fermentation is proceeding and there are indications that this enrichment will benefit tomatoes. The heat generated during fermentation will also be useful with an early planted crop.

By using straw bales isolated from the soil beneath with sheets of polythene, it is possible to replant with tomatoes only 7 or 10 days from the time of placing the straw bales in the glasshouse, provided care is taken in watering and the application of nitrogen fertilizers to the bales to ensure the right degree of fermentation before planting. Wheat straw generally retains its consistency best, though barley and oat straw have also been used successfully in similar experiments with cucumbers. Wire-tied bales are preferred and, where they can be obtained at £3–£7 per ton, the economics of the method seem quite satisfactory. In addition to the purchase of straw there will be the cost of polythene sheeting and a quantity of virus free soil or compost in which to set the plants on the bales. There will be a saving on dung or other organic matter normally required in preparing the houses for tomatoes and soil sterilization should not be necessary if polythene sheeting is used to isolate the soil below the bales.

The most suitable method and length of treatment for the bales before planting still needs to be determined but whether a "long" treatment of about 18 days or a "short" one of seven days is used, the bales need to be thoroughly soaked after bringing them into the glasshouse. In the long interval method the full quantity of fertilizer, containing 30 lb of nitrogen per ton of straw, is given in stages during the treatment of the bales. In the short method rather less nitrogen is used but the amount is made up in subsequent liquid feeding. With either method, a complete fertilizer containing potassium, phosphorus and magnesium is given and the bales should have actively fermented and their temperature be falling before the small bed of sterilized soil or compost is placed on top and the plants set out in it.

Whether bales are arranged lengthways down the house or across the house, each row of bales should take two rows of plants. With polythene under the bales, it is important that the ends of the wire ties should be upwards and not allowed to make punctures in the polythene through which the tomato roots will reach disease infected soil. The bales will settle as time goes by and the strings supporting the tomato plants should not be too tight. A general view of tomatoes grown by this method is shown in Plate II.

Watering must be carefully attended to and, as daily applications of small quantities are often necessary in the early stages after planting, some form of automatic or piped irrigation will often be advantageous.

Liquid feeding can be based on the leaflet *Liquid Feeding of Tomatoes* (S.T.L. 8) but it may be necessary to start the higher nitrogen feeds at an earlier stage than where plants are grown in the conventional way. This is certainly the case where the bales have been prepared by the short interval method and have thus received less nitrogen initially.

The technique has so far been used for only one season and a number of matters, especially the nutrition of the plants, require further detailed investigation but possibilities are promising for nurseries where soil infection with virus or eelworm is a problem. Growers who try the method should do so on a small scale to ascertain its commercial possibilities, though the full benefit in freedom from virus will not be obtained until the whole of a nursery is laid down to the method, so avoiding re-contamination of the plants from those growing adjacent in border soil.

P. G. Allen

LOAMLESS COMPOSTS

The recent publicity given to the use of loamless composts in this country may have left the impression that these composts are something new; it may not be generally known that most of the pioneer work was done in the United States of America over 20 years ago; some growers in Britain and Europe were using them for specific purposes even before that.

The work on peat/sand composts, started by the University of California in 1941, was prompted by the difficulties experienced by American nurserymen in obtaining good loam. Added to the fact that suitable loam was very scarce, there was the problem of salinity, particularly in areas of low rainfall where toxic salt concentrations build up very rapidly in the soil.

In Britain there is no problem of salt concentrations in the loam as rain washes out excess salts in the drainage water. Interest has however been aroused here recently in the use of loamless composts for other reasons, the main one being the increasing difficulty in obtaining good loam close enough at hand to the nursery and the cost of transporting it from a distance.

The initial work on loamless composts started at Fairfield in 1961 when relatively large scale trials were carried out involving the potting of cyclamen and gloxinia into a range of University of California mixes.

There are five basic U.C. mixes each with a different proportion of peat and sand and designated A to E. A is 100 per cent sand, B 75 per cent sand 25 per cent peat, C 50/50 peat/sand, D 75 per cent peat 25 per cent sand, and E 100 per cent peat. Each of these can be used in conjunction with one of six nutrient recipes which is chosen to fit the stage of growth of the plant.

Three of these mixes, C, D and E, were used in the trials, with nutrient content No. 2, which was recommended for potting on. The plants potted into these mixtures were compared with similar plants grown in the standard loam potting compost, John Innes No. 3. Four varieties of cyclamen were used in one trial, and in the other three varieties of gloxinia; the same range of composts was used for each.

The conclusions drawn from the results were that, of the loamless composts tried, the U.C. D II (75 per cent peat 25 per cent sand) was the most promising; it was the easiest to manage from the point of view of watering, it did not dry out as rapidly as the 50/50 peat sand nor did it, like the 100 per cent peat, waterlog easily; this 75/25 peat sand compost gave results most nearly approaching the high quality of the plants grown in the standard loam compost. Out of the 160 cyclamen plants grown in each compost 105 1st grade plants were marketed from U.C. D II as against 131 from the J.I.P. 3 loam compost.

None of the loamless mixes, however, gave quite as good results as the J.I.P. 3 loam mix, the most robust plants being produced from this standard compost. This was not unexpected as these loamless composts were not as high in nutrient content as J.I.P.3 and were recommended for use in conjunction with liquid feeding.

The aim was to evolve a loamless compost with long lasting nutrient qualities equal to J.I.P.3. No liquid feed was given to the experimental mixes in order to assess how far short they came of the standard compost and so obtain some basic information to work from in building up recommendations for a peat/sand mixture.

As a result of the observations made in 1961 it was decided not to continue with the 50/50 peat/sand mix for potting but to carry out a further trial with the 75/25 peat/sand and the 100 per cent peat and as a start increase the hoof and horn (the slowly available nitrogen) from $2\frac{1}{2}$ lb to 4 lb per cu yd of compost, keeping the rest of the nutrients in the recipe the same.

In addition another loamless mix based on 75 per cent peat and 25 per cent sand was made up with increased N, P and K over the U.C. D II, a compromize compost between this U.C. D II and J.I.P.3. This was called Fairfield "A" mix.

Pot plants grown in these three loamless composts in 1962 were cyclamen, coleus, gloxinia and F_1 hybrid petunia. *Primula malacoides* and *Primula*

obconica were grown in the two 75/25 peat/sand mixes, the 100 per cent peat being thought too retentive of water for winter flowering plants. All were compared with the standard loam composts.

The results of 1962 showed that plants of good quality had been obtained from both the 75/25 peat/sand mixes, in each case the Fairfield "A" being slightly better than the U.C. D II to which additional nitrogen had been added.

The 100 per cent peat had again proved very difficult to manage from the point of view of watering and it was decided to drop this compost from future trials and to concentrate on those based on 75 per cent peat and 25 per cent sand which were comparatively easy to manage.

In 1963 the Fairfield "A" mix was given extended trials with four other loamless composts based on the same ratio of peat and sand, two of which contained urea fomaldehyde in place of the hoof and horn as a source of nitrogen.

The best pot plants were those from the Fairfield "A" compost and the standard loam composts, J.I.P.2 and J.I.P.3. This led to present work in which plants are being grown from seed to maturity in loamless composts alongside others in the standard loam composts for comparison.

Jean Kinnings

CONTROLLED FLOWERING OF *PRIMULA MALACOIDES*

Those commercial flower crops which are affected by daylength (or, more correctly, the length of the dark period), either in their vegetative growth or in the production of flower buds, can usually be subjected to the "precision" type of horticultural production and such techniques are becoming increasingly popular. The controlled flowering of the chrysanthemum began in the United States, and this revolutionary method for cultivation has become established in Britain over the past ten years. Again, with poinsettias in the U.S.A., the controlled modification of the natural daylength, means that flowering time is now much less subject to chance. Other crops in which daylength affects the initiation of flower buds include antirrhinum, begonia, fuchsia, kalanchoe, dahlia, carnation and calceolaria, to mention only a few commercial flowering plants.

The purpose of this article is to describe how, in conjunction with temperature, daylength was altered artificially to control flowering in *P. malacoides*, a plant which has not yet found a place among precision-grown crops, but which may be added to the foregoing list.

P. malacoides has been grown for many years as a pot plant in cold frames and cool glasshouses, where it flowered naturally in the spring. The pale pink species has now been superseded by varieties with larger flowers and a range of colours from bright pink to rosy crimson. Recently selections for flowering in time for Christmas became available. The late Dr. Kenneth Post pointed out in 1942 that *P. malacoides* var. *Erikssonii* would form flower buds at 50°F, regardless of length of day, and at 60°F during the short days of a New York winter. He recommended that the glasshouse temperature should be reduced to 50°F, and the daylength reduced to 10 hours, 10 weeks before bloom was wanted. This did not appear to have been tried in Britain.

In 1962, an experiment was begun at Efford Experimental Horticulture Station to show the effect of sowing time and short-day treatments on time of flowering, with particular emphasis on the production of plants suitable for sale at Christmas. It appears that the British market demand is largely limited to the Christmas season at the moment.

An early-flowering variety, Christmas Rose, and a later one, Fire Globe, were sown at fortnightly intervals from 15 June to 13 July. The minimum night temperature for germination was 65°F, followed by 55°F until the short-day treatments began. Thereafter, it was maintained at 50°F. Ventilation was given during the day to promote airy conditions. Light intensity in the house was good. With the experimentally treated plants the "night" period was increased to 13 hours by shading with black polyethylene sheet from 6.30 p.m. to 7.30 a.m. during two 30-day periods which began on 1 September for the earlier treatment, and on 15 September for the later one. The development of these plants was compared with that of unshaded control plants.

Plants were recorded as flowering when all the flowers in the earliest basal whorl had opened, and the mean flowering time in each treatment was then calculated. Table 1 shows that the growing time for the shaded plants was reduced with the later sowings, and that this effect was more marked with Fire Globe than it was with Christmas Rose. In fact, with the latter (selected for Christmas flowering) sown in mid-June, early and late shading actually *delayed* flowering for 6 days and 2 weeks, respectively, when compared with the controls. The greatest hastening effect was with Fire Globe, sown in mid-July, and shaded for 4 weeks beginning on 1 September. In this case flowering was advanced by 3 weeks.

TABLE 1

Primula malacoides—Days from sowing to flowering under three growing methods

Treatment	Variety	Sowing date		
		15 June	29 June	13 July
Shaded 1–30 Sept.	Christmas Rose	152	144	128
	Fire Globe	167	149	132
Shaded 15 Sept.–15 Oct.	Christmas Rose	160	144	131
	Fire Globe	177	159	145
Control unshaded	Christmas Rose	146 (8 Nov.)	149 (25 Nov.)	137 (27 Nov.)
	Fire Globe	179 (11 Dec.)	164 (10 Dec.)	153 (13 Dec.)

Where the time taken to flower was calculated from the *start of short-day treatments* (Table 2), a fairly consistent pattern was seen to emerge. With Fire Globe there was a remarkable similarity in the periods from the start of short-days to flowering, apparently regardless of differences in sowing date or shading time.

The effect with Christmas Rose was generally less marked. This could be explained on the basis of this early variety having a greater response to natural shortening days, and initiating flower buds during a shorter dark period (and thus earlier in the autumn) than did the later type of primula.

TABLE 2

Primula malacoides—Days from start of short-day treatments to flowering

Treatment	Variety	Sowing date		
		15 June	29 June	13 July
Shaded 1–30 Sept.	Christmas Rose	75	81	79
	Fire Globe	90	86	83
Shaded 15 Sept.–15 Oct.	Christmas Rose	69	67	68
	Fire Globe	86	82	82

These results would probably have been even more consistent had it not been for considerable variation among the seed-raised plants themselves. For both experimental and commercial purposes, it would be desirable to have available more uniform stocks of *P. malacoides*.

Plants from the mid-June sowing were large and leafy and were liable to scorch in an unshaded glasshouse. The scorched areas predisposed the plants to attacks of *Botrytis*. On the other hand, the mid-July, and latest, sowing resulted in easily manageable plants of a satisfactory size and habit.

Plants of both varieties, both treated and control, were in flower and saleable by Christmas, so it is obvious that, in conjunction with a night temperature of 50°F, natural shortening days added their influence to that of the artificially shortened days in inducing flowering, especially with Christmas Rose. Therefore, at a latitude of 50 deg 44 min N., it appears that short-day treatment might begin approximately 12 weeks (with a late variety), and approximately ten weeks (with an early variety), before flowers are required.

This suggests that, with suitable short-day treatments, even later sowings might be made for Christmas flowering. Production costs in the present study have been considerably reduced by sowing in mid-July, a reduction in growing time of up to two months compared with the usual May or June sowing. These results also prompt the suggestion that, where a night temperature of 50°F can be maintained, reduced daylength may be employed for precision flowering of *P. malacoides* at other times of the year.

Experiments are in progress to determine if this plant can be "grown to order" with an even greater reduction in growing time. This could make *P. malacoides* an ideal pot plant for mass production and inexpensive sale in chain stores and supermarkets. Plants produced by the shading method are shown in Plate IV.

D. R. Smith

THE NATIONAL APPLE REGISTER

Growing at the National Fruit Trials at Brogdale in Kent are large and unique collections of most kinds of hardy fruits. They are not there merely to impress the visitor; among other important functions they also play a large part in the work of building up the national fruit registers.

People in the horticultural world have for many years felt that there should be authoritative registers of all varieties* of flowers, fruit, vegetables, shrubs and so on. A number of these registers have been started already, including the apple register, but it was not until last year that the National Fruit Trials was officially recognized as the national registration authority for fruit varieties. This means that registers have to be compiled for each kind of fruit grown out of doors in Great Britain, adding new varieties as they are named.

Why is registration necessary? First of all, the naming of any class of beings, whether animal or vegetable, should be clear and unambiguous—one species, one name. The naming of varieties is an extension of this principle. The naming of fruit varieties has become extremely confused over the years, particularly among apples, pears and plums, and in sifting these names, establishing the correct ones and recording the necessary historical and descriptive detail, a register is automatically created. It is only common sense to add new varieties as they are named. We hope by this means to keep the nomenclature uncluttered by synonyms and to provide a source of useful information for growers and pomologists alike. The government certification schemes call for accurate naming, and so does the Plant Breeders' Rights scheme which has come into being, and it must surely be an advantage to both the nurseryman and his customer to know that there is an accurate register to refer to in case of doubt.

It is very important to use the correct and full name of a variety, as using the wrong one may lead to disappointment and financial loss. When we speak of 'Wellington' we ought to mean the modern American apple, but quite likely what we do mean is the old English cooker whose correct name is 'Dumelow's Seedling' but which can also be found listed as 'Normanton Wonder'. In Germany 'Oldenburg' is 'Geheimrat Dr. Oldenburg', but over here we are probably referring to 'Duchess of Oldenburg', which on the continent is called 'Charlamovski' but whose original name was 'Borovinka'. 'Laxton' generally means 'Laxton's Superb', but there are half a dozen good apples of Laxton's raising, so it could almost equally be one of those.

The correct name of a variety is generally the first published one, but occasionally a name has been changed at the request of the raiser or introducer, such as 'Charles Ross' apple which started out as 'Thomas Andrew Knight'; or a synonym may have become so well established that it would be impossible to persuade people to go back to the original name—who is going to call 'Allington Pippin' 'South Lincoln Pippin'?

Before registration of new varieties can begin, a register must be built up of all varieties now in existence, or thought to be, under their correct names, and the more and the less important differentiated typographically. As there are

* In this article the word "variety" is being used, though strictly speaking "cultivar" is more correct. This is an international term for a variety that has arisen in cultivation as distinct from a botanical variety, and it will only be a matter of time before it is used with as much ease as "variety" is now.

many thousands of varieties in this country (including over 2,000 apples in the National Fruit Trials alone), this is a colossal task. All synonyms will be listed, both in alphabetical order and under the correct name, and a list of references given, with the best one from the point of view of description and/or illustration specified. There will be a brief but factual history (no guesswork as to parentage), and a description, made wherever possible from living material, otherwise from published works, brief, but enough to tell the enquirer whether he is on roughly the right tracks; he can then make further reference to one of the authorities cited.

When this part of the register is complete, new varieties will be accepted for registration. The name submitted would have to conform with the International Code of Nomenclature for Cultivated Plants and the variety would need to be a new one and not an old one resuscitated and renamed. Ideally this should be done by growing it, but as this would take too long, the original tree would be inspected, the fruit and foliage compared with similar varieties growing in the collection, and published descriptions checked.

For hundreds of years fruit varieties have been the object of widespread exchange. Travellers between Britain and the continent carried grafts and trees; early settlers in the New World took with them trees and scions as well as seeds, and, particularly in the 18th and 19th centuries, learned pomologists and the more scholarly nurserymen, exchanged material very freely. All this was admirable, but it did mean that synonyms proliferated (Blenheim Orange, for instance, has thirty-five published ones, and is suspected of having about a dozen more scattered through the National Fruit Trials collection) as when a variety crossed a border it generally acquired a new name, or at least a translation, occasionally an erroneous one. Translations were sometimes retranslated into something slightly different from the original, and so the muddle continued. These names have to be sorted and listed and the correct name established. This is done by searching the British literature covering the last hundred years, checking the findings against older works where necessary, against the relevant literature from the United States and most of the European countries, and finally against the National Fruit Trials collection.

Although this work has at times been very tedious, some interesting facts have emerged and also many very peculiar names. Who, for instance, thought that 'Sweet Sheep's Nose' was a good name for an apple? or 'Dog's Snout'? To us they suggest ugly shapes but unlike ourselves, our ancestors were much more interested in the flavour of the apple than in its appearance. Quite a lot has been written about the older varieties but it is sometimes puzzling to sift the facts from speculation. Often the slenderest evidence has been quoted as proof, and sometimes a fact has been misquoted by one author and the mistake perpetuated by others, so reference has to be made whenever possible to the original sources.

Some obviously good varieties have disappeared. Where, for instance, is 'Ord's Apple', raised nearly 200 years ago, with a well authenticated history, still grown at the beginning of this century but since disappeared? All authors were agreed on its excellence and it should be well worth finding. Maybe, like 'Cox's Orange Pippin', it only needed modern sprays to make it easy to grow, but unlike Cox, it does not seem to have survived long enough for the sprays to be tried on it.

In spite of many attempts to resolve it, the confusion in variety names persists, and publication of an authoritative register is more than ever necessary. The major fruit growing countries are agreed on this and the first step will be the compilation of national registers, later to be combined in an international one. Impetus was given to this project last summer when a meeting was held at Brogdale of representatives of most of the important fruit growing countries in the world to discuss the form the registers should take, basing the discussions on the work already done by the National Fruit Trials. If a further stimulus is needed, perhaps the publication in a few years' time of the British Apple Register will provide it.

Muriel W. G. Smith

BLACK CURRANT LEAF DISEASES

In collaboration with Long Ashton Research Station, experiments on the control of black currant leaf spot (*Pseudopeziza ribis*) have been in progress since 1959 on the varieties Baldwin and Mendip Cross. Leaf spot was exceptionally damaging in most commercial plantations in the summer of 1963 and appears to be a disease that, although largely controlled by weather conditions, yet is becoming more serious each year. This might be partly due to the replacement of lime sulphur by other acaracides for black currant gall mite, since lime sulphur has some effect on leaf spot. It is known, but as yet unexplained, to be much more damaging on older, than younger bushes. This interesting fact was clearly demonstrated at Efford in 1963 where a number of two year old replant bushes, amongst nine year old bushes, remained remarkably green and uninfected when the older, adjacent, bushes were severely infected and defoliated.

The N.A.A.S. advisory plant pathologists, in co-operation with the Ministry of Agriculture, Fisheries and Food Plant Pathology Laboratory, are currently undertaking a careful survey of the incidence of leaf spot each year, noting the date of first infection and the development of the disease and relating this information to the stages of growth of the bush and to meteorological records, including records from the Hirst wetness recorder. Ultimately this information may enable more accurate assessments to be made of the type of weather conditions conducive to severe infection.

Effects of the Disease

The fungus overwinters on infected, fallen leaves and in the spring ascospores are released from these leaves which re-infect the new unfolding leaves on the bushes. From these primary infections further infection takes place rapidly under conditions favourable to the disease.

Leaves were collected each autumn at Efford, and overwintered in the open in small boxes made of wire netting, thus subjecting the leaves to natural conditions. In the early spring the leaves were sent to Long Ashton Research Station for examination and confirmation of the date of first ascospore release.

A standard method of assessment, devised by Dr. Corke of Long Ashton, was used each year to record the spread of the disease. These records show, on unsprayed control plots, the marked seasonal variation that can occur. In 1963

unsprayed bushes were nearly 100 per cent infected by the end of July, resulting in much shrivelling of the fruit and crop reduction, yet in other years this stage was not reached until September.

Spraying Experiments

In the original experiment two fungicides, zineb (1½ lb/100 gal) and captan (2 lb/100 gal) were compared at high volume rates (300 gal/acre). Results showed zineb to be the more efficacious (see Plate IV). Time of application was also studied and two pre-picking sprays, in mid-May and mid-June, were compared with two post-picking applications in August and September. One treatment had zineb at all four times and there were unsprayed controls.

The experiment started in 1959, spray treatments finished in 1961 and the 1962 crop was also recorded, since it had been clearly shown that spray treatments the previous year can influence the following crop. On the 4 × 8 ft plant the *calculated* cwt/acre crops are shown in the table.

	MENDIP CROSS			BALDWIN		
	1960+ 1961	1962	Total	1960+ 1961	1962	Total
No spraying	173	97	270	150	96	246
Two before picking zineb sprays	199	115	314	195	119	314
Two before and two after picking zineb sprays	204	133	337	211	124	335

Regular sprays have an accumulative effect, not only on the crop, but on the amount of infection. After-picking sprays reduced the amount of infection on the fallen leaves.

As a result of no spraying in 1962, the acre plantation became evenly re-infected again and in 1963, four early sprays of zineb at about 14 day intervals, were compared with unsprayed controls. The first spray was applied 27 March the last 30 April. Leaf spot was found on the unsprayed bushes on 15 May but on the sprayed bushes not until mid-July. The fruit on the unsprayed bushes was badly shrivelled and unsaleable and the sprayed bushes gave nearly 2 lb/bush more weight. After picking, the leaf spot spread rapidly on the sprayed bushes and a post-picking spray would have been well worth while.

The experiments are continuing. It is suggested that, depending on the severity of the disease in the plantation, three to four zineb sprays applied at grape stage, and thereafter at two to three weekly periods, are well worth while to delay the infection. Depending on the amount of infection a further spray, or sprays, *immediately* after picking will reduce the carry over of the disease to the next year and also help to protect the later foliage.

Irrigation

As leaf spot is spread by spores and these are readily water carried, irrigation can seriously and rapidly spread this disease. This problem was acutely shown at Efford on an irrigated plantation, where the early zineb sprays gave little control.

Users of overhead irrigation systems may face increasing trouble from the build up of this disease and should use sprays after picking, and after irrigation, in order to try to reduce the over-wintering infection. The practicability of applying sprays through the irrigation lines obviously needs examination.

Rust

Rust (*Cronartium ribicola*) causes bright orange patches on the leaves of black currants and is an unusual disease, erratic in occurrence and not normally considered important. The fungus causing this trouble has a most complicated life history and to complete its growth must infect species of five-needle pines. Captan and zineb do not appear to have any effect on the disease.

Mildew

White powdery patches on the young tip leaves are caused by the same fungus that causes a serious disease of gooseberries (*Sphaerotheca mors-uvae*). Cotswold Cross is a variety that seems particularly prone to attack. In 1963 there were many reports of mildew also infecting many other varieties. This disease might become serious if the techniques of growing black currants are changed over the next decade and in particular, if plantations are produced by close planting of cuttings and heavy summer pruning of fruiting branches to feed picking machines.

Experiments on gooseberry at Efford and Luddington 1954–61 showed that dinocap (1 lb/100 gal) gave a good control and compared favourably with a washing soda/soft soap mixture. Unfortunately zineb gave either a poor control of this disease or no control at all. It may therefore become necessary to use one or two dinocap sprays after flowering to protect the foliage at the tips of shoots.

Hilary M. Hughes

RECENT RESULTS WITH THE ASPARAGUS CROP

Luddington Experimental Horticulture Station is situated near the Vale of Evesham, one of the main asparagus producing areas in the British Isles, which has over $\frac{1}{4}$ of the total 1,500 acres of asparagus grown in England and Wales and produces over $\frac{1}{3}$ of the total weight because the yields are heavier than the national average. The asparagus in the Vale of Evesham is grown on heavy calcareous clay soils in small acreages where the row spacing is close and entails much costly hand labour.

A completed spacing experiment at Luddington gave definite and consistent results showing that with rows closer than 4 ft 6 in., the total crop was not increased and at 3 ft more sprue (spears below 0·25 in. diameter) was produced. At 6 ft the yield was reduced by 25 per cent compared with 4 ft 6 in. At all inter-row spacings 1 ft in the row gave higher yields than 2 ft.

In designing new trials an attempt has been made, by increased mechanization, to combine high yields with lower costs of production. To achieve this a 1 × 6 ft spacing has been adopted for all experiments in which ridge methods of growing are employed. 6 ft is the closest spacing at which a standard Massey-Ferguson tractor can be used for ridging and cultivating. In all the new experiments, annual weeds have been kept under control by a spring application of monuron

at 2 lb/acre active ingredient (a.i.) or simazine at a similar rate, and in wet seasons it has been necessary to give an additional spray of diquat 6 or 12 oz a.i. when no spears were above ground. Perennial weeds, thistle and couch grass, have caused some trouble and have either been spot treated with MCPA at $1\frac{1}{2}$ oz acid equivalent in 2 gal water or dug out by hand.

Variety Trial

The first experiment to be laid down under the above mentioned system is a comparison of six varieties. The one year old crowns were planted in spring 1960 and records from two cutting seasons have now been kept (see Table 1). In the first season, only a light cut was made and cutting stopped on 8 June, but in the second season a full season's cut to 20 June was made.

TABLE 1

Total Yields from Varieties in 1962 and 1963

Variety	Actual No. sticks cut in 1,000s/acre			Calculated wt. in cwt/acre			% in extra-select grade	
	1962	1963	Total	1962	1963	Total	1962	1963
K.B.F.	63·1	83·8	146·9	28·6	34·6	63·2	18·6	11·6
58148 (Dutch)	73·2	106·2	179·4	24·4	42·2	66·6	5·9	6·7
58160 (Dutch)	76·8	124·5	201·3	35·0	53·1	88·1	16·3	10·4
Roberts (USA)	57·0	66·4	123·4	26·7	26·5	53·2	22·4	11·6
Raritan (USA)	51·2	66·6	117·8	21·4	23·4	44·8	12·6	5·7
Giant Mammoth	87·9	123·8	211·7	27·2	43·0	70·2	5·6	3·0

Asparagus yields should show a substantial increase in the first few years of production, if the beds are to maintain a high yield for several years, and only the Dutch and local Giant Mammoth varieties have done this. The local variety shows a good total yield but does not produce many largest size sticks (over 0·7 in. diameter). All the varieties have yielded above the national average (20 cwt/acre) and most are above the Vale of Evesham average of 28 cwt/acre. Each variety in the trial occupies about $\frac{1}{20}$ acre. The Dutch all male variety 58160, has a disadvantage in that it throws both green and purple budded spears which have to be marketed separately. It is hoped to keep records from these varieties for at least seven years so that information can be collected on the useful life of asparagus beds.

Size of Crown at Planting Time

One year old crowns from an outdoor seed bed of variety Giant Mammoth were lifted in spring 1961 and graded by weight into 3 grades:

1 Small crowns (5–10 gm)
2 Medium crowns (10–20 gm)
3 Large crowns (over 20 gm)

These were planted in a replicated trial from which a light first cut was taken in 1963 (see Table 2). In the summer of 1961, immediately after planting, the

various crown sizes were easy to distinguish by the difference in the amount of bower growth, the largest crowns being most vigorous. In the second season it was not possible to pick out any differences by eye and the first cut has shown only small differences between the treatments.

TABLE 2

Yield from First Year's cut of Crown Size Trial

Crown size	Total Yield 1,000 sticks/acre	Extra Select 1,000 sticks/acre	No. cut in 1st 7 days
Small	56·9	3·32	4·03
Medium	61·8	3·24	4·51
Large	62·1	2·82	5·06

In the next cutting season, and for the rest of the life of the trial, it is intended to superimpose different times of ending the cutting season on these plots. Cutting will end about 10 days early on some plots and extend for 10 days longer on others, while the remainder will be cut for the usual season (until about 20 June).

A second trial using crowns of different sizes was planted in spring 1962. These plants were raised from two sizes of seed which was germinated in a propagating house and pricked out into cold frames when large enough to handle. The seeds were graded for size using a No. 6 sieve which gave 1,200 and 1,336 seeds per oz. It was found that the seed germinated over a long period, so that there were four pricking out dates at approximately monthly intervals starting on 1 June. At the earlier dates the larger seeds had a higher percentage of germination. By the following season there were 8 different crown sizes from the 2 seed sizes × 4 pricking out dates and these were planted in a replicated trial. No records have been taken yet but again, in the first season big differences showed in bower growth, while in the second season the differences were very small. The variety is an all male line raised by the N.V.R.S. and the heavy bower growth gives promise of a good yield.

Green Asparagus from Unridged Beds

One year old crowns of variety Giant Mammoth, raised in an outdoor seedbed, were planted in 1961 in 4 ft 6 in. rows at 1 ft in the row. In some plots two extra rows were planted 1 ft apart at either side of the first row, making 3 row beds with a 2 ft 6 in. path between. Half of the single rows are to be ridged in the traditional manner but the remaining single rows and the three-row beds, are to be left flat and the asparagus cut at ground level and sold "green", that is, without the portion of white fibrous stem. The 4 ft 6 in. spacing was used because, if ridging is unnecessary, the tractor can be used in the closer spaced rows. The first cut will be made from these beds in 1964. This method of growing is used extensively in America and has already aroused considerable interest among growers in England.

Conclusion

Mechanical cultivations are proving satisfactory. To date, some varieties are more productive than others. In the second year, there is little difference in bower production, from crowns that were of different sizes at planting time.

Jean M. Garthwaite

ANTIRRHINUMS FOR CUT FLOWER PRODUCTION

In the last decade antirrhinums have been established as an important glasshouse crop in the United States of America, the annual production being valued at £1·6 million in 1959. This success, of what is virtually a new cut flower, can be mainly attributed to the achievements of the geneticists who have succeeded in developing markedly improved varieties, most of them F_1 hybrids. These hybrids have been bred to enable high quality blooms to be produced throughout most of the year, and particular varieties are best suited to flowering at specific periods during the year. To simplify the choice of variety they have been classified into four response groups, according to their sensitivity to daylength and temperature.

In Britain the newer hybrids have now been grown for several years. At first there were difficulties in finding a market for the blooms, but in the last 2–3 years it appears that the consumer has begun to appreciate the value of the antirrhinum as a cut flower, for demand has increased each year. In this country, the most successful crops have been those marketed in the spring and early summer, and it has been with this period that the studies at the Lee Valley E.H. Station have been concerned. Flowers of excellent quality have been produced in heated glasshouses using Group II varieties, in March and April following sowings made in mid-September, or from a mid-October sowing followed by four weeks illumination during the seedling stage (see Plate III).

Antirrhinums have been included in a heated mobile glasshouse rotation. In 1963 a crop was uncovered in mid-April, and gave good quality spikes in the open in early June. This crop has also been grown as part of a study of the effects of protection by frames on the flowering of annual flower crops. Plants set out at the end of March in frames and given protection by Dutch lights until they reached the glass, flowered about two weeks before others grown without any form of protection. In another study it has been demonstrated that early flowering can be ensured by allowing only a single stem to develop on each plant. Where a plant was stopped and allowed to develop 3–6 stems, flowering was delayed by 15–25 days, and the spikes produced were of poorer quality than those borne by single stemmed plants.

J. Whetman

New Items of Interest in the Experimental Programme

CHANGES IN THE LEY FERTILITY EXPERIMENT

Results from the first 10 years or so in this experiment, in progress on six Experimental Husbandry Farms, were described in the previous Progress Report. From a consideration both of these results and of changes which have taken place in general farming patterns since the trials were laid down, some modifications are now being made.

Firstly, it is necessary to test grass management at a higher level of nitrogen than was originally provided for. As new ley-conserved plots are sown they will receive up to 240 units of N/acre annually and the corresponding ley grazed plots will receive either this same high rate or 120 units N/acre annually. In order to accommodate this change it has been necessary to forego the lucerne leys, a decision not out of keeping with present day fashion; lucerne currently represents a very small proportion of the total temporary grass acreage.

Secondly, the growing of potatoes as a first test crop after the treatment sequences is now less representative of farming practice than it was 15 years ago and the wheat test crop will take first place as the new leys are ploughed out. This is linked with the need to examine, more critically than has been possible in the past, the nitrogen contributions by leys in the succeeding wheat crop insofar as it will now be possible to test a wider range of nitrogen dressings.

Thirdly, additional tests of phosphate and potash rates to the remaining potato crops grown as a first test crop are proposed as a means of seeking an explanation of those cases where reduced yields of potatoes have followed the arable treatment sequence.

REDUCED CULTIVATIONS IN CEREAL GROWING

Earlier attempts on Experimental Husbandry Farms to grow arable crops without ploughing resulted in very low yields, largely due to intense competition from those weeds which were not then controllable by herbicides. Recently however, with the increasing availability of means of complete weed control by chemical methods, the necessity and desirability of traditional cultivation practices is once more in question. The situation is particularly interesting in the case of cereal crops, where, unlike that of root crops, the harvesting methods do not cause soil disturbance. If ploughing can be avoided, there is then the possibility of restricting soil disturbance to a shallow horizon only a little deeper than present drilling depths. In time weed seeds could be eliminated from such an horizon.

With the help of the Weed Research Organisation, new studies are now beginning, on several Experimental Husbandry Farms, to examine ways and means of exploiting the situation. As a preliminary investigation in the first year, four principal methods of getting the seed into the ground have been compared. The first, as a "control" method, is conventional ploughing and seed bed preparation, and normal farm drilling. The other three methods follow the killing of existing vegetation, be it grass sward or weeds in stubble, by a non-residual weed killer. The three "reduced" cultivation methods are normal farm

drilling after shallow (3 in.) discing or rotavation, disc seeding or slit seeding. There is of course some soil inversion with rotavating or discing and with disc seeding, but none with slit seeding.

The trials are in progress on the full range of soil conditions covered by the Experimental Husbandry Farms as represented by Gleadthorpe (light land) Bridget's and High Mowthorpe (medium soils) and Rosemaund and Boxworth (heavy land). There are parallel studies on the light land farms of the Weed Research Organisation and the Norfolk Agricultural Station.

Generally machine performance and the resulting brairds in the first autumn, have been encouraging but the suitability of the various machines for the different soil conditions will be taken into account in planning the next stage of the investigations, which will consist of growing several successive cereal crops by conventional or "reduced" cultivation techniques. Problems of compaction by harvesting machinery may be important here.

MOIST BARLEY STORED IN A LARGE PLASTIC BAG

Experience in America and in the U.K. has shown that moist barley can be kept in bulk, without deterioration, provided the bin or silo is air tight. However, the present types of sealed silo, holding 100–200 tons of grain, are relatively expensive per ton of grain stored and do not meet the needs of the smaller farmer who wishes to store 20–30 tons undried grain for stock feeding. One solution is to store in polythene sacks which can be sealed by heat treatment, or wire tied.

An alternative, suitable for dealing with grain from a tanker combine, is to store in a single large plastic bag contained within a cylinder of welded-steel mesh. At Gleadthorpe in 1963 a bag of this type, with a capacity of 10 tons of grain, was filled with barley varying from 19 to 31 per cent moisture content with an average of 23 per cent. The bag was filled by auger from a hopper into which the trailers from the combine emptied their loads. After filling, the neck was drawn together, covered with a plastic bag and tied with several wire ties. The silo was erected in the open on a prepared concrete base and, in order to discourage vermin, a 3 ft fence of chicken wire was erected on this base, a few inches away from the wall of the silo.

SALT CONTENT IN IRRIGATION WATER

As will be remembered from the effects of the disastrous floods on the East Coast in 1953, salt water is highly injurious to many crops and can cause serious damage to the structure of heavy soils. Normally, for irrigation purposes, the amount of salt in river water only reaches a dangerous level in tidal areas but of recent years the salinity of rivers in certain industrial areas in the Midlands has increased very markedly. It is believed that this change is due to the high salt content of water discharged into the rivers from coal mines, especially those with deep workings. Water tests show a wide variation in salt concentration between rivers, and from season to season in the same river, but generally speaking there has been an all round rise in the last two or three years; for example, at Gleadthorpe in 1959 the chloride concentration in water of the river flowing

through the farm was 160 ppm or 0·016 per cent: throughout the summer of 1963 it was around 300 ppm or 0·03 per cent. Crops vary in their sensitivity and it is unfortunate that potatoes, which is one of the most responsive crops to irrigation, is one of the least tolerant to salt. However, the total quantity of salt applied over the years is a more important consideration than the salt content of the water, so that a higher salinity can be tolerated if the rate of irrigation use for a particular crop is limited or the land is not watered every year. Damage to potatoes from excessive salt shows itself in reduced yields without any very obvious symptoms. In order to assess the actual loss in yield that may occur, it is clearly necessary to compare potatoes irrigated with dangerously saline water with those receiving the same amount of salt free water from another source.

This was done at Gleadthorpe in 1963 on small plots which were watered by hand, either using river water with 0·03 per cent chloride or mains water with 0·01 per cent chloride, the aim being as far as possible to irrigate at the same rate of application as normal commercial equipment. After a single experimental watering, rain precluded further irrigation and the results were inconclusive, but it is hoped to repeat the investigation in 1964.

CONTROL OF SKIN SPOT IN POTATOES

Skin spot in potatoes is a widespread disease caused by the fungus *Oospora pustulans*. Most stocks of seed potatoes carry some degree of infection. Seed which is badly infected produces fewer and weaker shoots than unaffected seed and the resulting crop is often gappy and yields are lighter. The development of the disease is favoured by cold damp conditions at harvest and during storage, so that after a wet harvest infection becomes widespread. If infected seed is then planted in poor conditions the following spring, serious reductions in yield can occur. Factors such as early boxing and sprouting to encourage the quicker development of the seed when planted, reduce the efforts of skin spot infection.

Trials are being conducted at High Mowthorpe E.H.F. to study the effect of storage and time of boxing on the development of skin spot in seed and the subsequent yield of potatoes. The possibility of controlling skin spot in potatoes by use of a mercurial fungicide is also being investigated.

These studies began in 1962 as observation trials, full scale experiments were laid down in 1963. They are to be continued for a number of years.

SUGAR BEET SEED PRODUCTION

The programme of research into sugar beet growing has been recently extended. One very important objective is to ensure that seed is produced without endangering the root crop with disease. To this end, stecklings are being grown experimentally in districts and on types of soil hitherto considered unsuitable for seed production but which may now prove quite satisfactory because of advances in pest and disease control. Sites sown in 1963 include one on blowing sand at Gleadthorpe just west of the Great North Road and one at Bridget's on the chalk soils of the southern counties.

Another important consideration is to produce seed of the right size for processing without any loss in germination percentage or vigour. Husbandry

factors which can affect this aim include the time of sowing and the spacing of the stecklings. For this reason, the main experimental comparisons comprise two dates of sowing in the late summer and two row widths, 20 in. and 10 in. Appropriate treatments with granular insecticides or systemic sprays were carried out in the autumn to control aphids and restrict the spread of virus and next year, when the seed crop is produced, the intention is to sub-divide the plots to test alternative methods of weed control and insecticide treatment, or to vary the plant spacing in the row.

COW SLURRY ON GRASSLAND

One of the problems associated with slatted floors is the disposal of the slurry which accumulates beneath them. In 1963 an experiment was started at Trawscoed Experimental Husbandry Farm to measure the nitrogen replacement value of cow slurry applied to grassland. Three rates of application were used; 1,500, 3,000 and 6,000 gallons of undiluted slurry per acre. The slurry was analysed chemically to determine the nitrogen content and equivalent amounts of nitrogen were applied to other plots as sulphate of ammonia. The whole area received a basal fertilizer dressing of 120 units P_2O_5 per acre and 120 units K_2O per acre.

It was intended that applications of slurry should be made in mid-winter and at the end of the winter. Owing to severe weather, the first application was delayed until March and the second application was made in April. Cuts were made in July and August to assess yields.

The results of the first year's work have shown a promising increase in yield following applications of slurry. The experiment will be continued for several years with the addition of a further series of winter applications to plots which will be defoliated in February. Yields will be measured as in 1963.

CALF REARING IN CONTROLLED ENVIRONMENT

Calf mortality is affected by environment and the provision of a precise control of temperature, ventilation and relative humidity in a calf house may be economically justified if it reduces rearing losses. There is also some evidence to suggest that the environment experienced in early calfhood has an effect on the subsequent performance and health of cattle.

To investigate these factors, a calf house at High Mowthorpe has now been adapted so that the effect of the early environment can be studied. A brick built house 84 ft long, 14 ft wide and 13 ft to the ridge, has been divided into two halves by building a wall across the width of the house. Each half can house 24 calves to 12 weeks of age.

For the past two years, the ventilation of the undivided house has been achieved by using four 9 -in. three speed extractor fans, and varying the rate of extraction manually according to conditions. This arrangement has generally provided a reasonable standard of air conditioning and the temperature has been kept at approximately 50°F. In extremely cold or misty weather, however,

the internal conditions have not been ideal for calves, as it has been impossible to maintain a reasonable temperature by reducing the ventilation rate, without causing condensation on the roof above the calves.

One end of the house has been left in this condition to act as control, whilst the other end has been adapted, so that the temperature can be kept up without reducing the ventilation below the desirable minimum rate. This has been achieved by increasing the insulation, using more ventilation fans and adding electric fan heaters. The fans and the heaters are automatically controlled so that a wide range of preselected temperatures and ventilation rates can be maintained, whatever the outside conditions.

Initially, matched groups of calves will be housed in each end of the house for 12 weeks before being joined together in fold yards or out on grass. Records will be kept of the health and liveweight gains of the cattle throughout their lives.

PROGENY TESTING OF RAM LAMBS

Evidence on the extent to which a high growth rate of a ram is reflected in the growth rate of his progeny is very limited and such evidence as exists is somewhat inconclusive.

Tests are now in progress to provide additional information on this subject. Weighings at birth and periodically afterwards are made of twin Suffolk ram lambs kept together under the same system of feeding and management. High and moderate gain ram lambs are then selected and these "on-the-farm" performance tested sires are then put to matched groups of Half bred ewes on Boxworth or High Mowthorpe Husbandry Farms. In this way it is hoped to establish whether the rate of liveweight gain of progeny from "high-gain" rams is different from that of "medium-gain" rams.

It is necessary to test about 50 rams to produce meaningful results and this is being achieved by using about eight rams on each Husbandry Farm in each of three seasons. Ram lambs from the 1962 crop were the first to be used and so the test will not be completed until progeny from the 1964 ram lamb crop have been recorded in 1965.

BREEDING ANEMONES FOR WINTER PRODUCTION

Nearly all the anemones at present grown in this country are produced from corms imported from Holland, where the parent stocks are grown under quite different conditions from those in which flowers are produced in Devon and Cornwall. Under this system of importing corms, selection for winter hardiness or resistance to downy mildew is virtually impossible. A programme of selection and breeding has however been started at Rosewarne E.H.Station in collaboration with the Glasshouse Crops Research Institute and it is hoped to produce stocks which will be more resistant to cold weather during winter and to disease. In addition it is hoped to re-investigate the possibility of producing anemones directly from seed, a method which was formerly used by some growers.

ASTILBES: RESPONSE TO LOW TEMPERATURE TREATMENT

Many herbaceous perennials require a period of chilling corresponding to the low winter temperatures of their normal habitat, before they respond to the warmer temperatures used in forcing. An outstanding example of this is rhubarb for which the temperature requirements of each of the main varieties used in forcing are now known with accuracy. An attractive decorative plant for which similar information will be useful is the Astilbe. It might well be used as a pot plant for the winter trade if a means could be found of bringing it into growth at the required time. Investigations of its chilling requirements are now in progress at Stockbridge House, and it is hoped it will be possible, by suitable low temperature treatment before forcing, to bring the flowering period substantially earlier than has been possible in the past.

STRAWBERRY VARIETIES FOR MAIDEN CROPPING

Production of strawberries from maiden (one-year) plants, by early planting of runners the previous August or September, is an important technique in the early strawberry areas of the south and west of England. Provided a strong plant is produced, good crops of large berries, which are easy to pick and not so liable to fruit rots as berries from older beds, are readily obtained. Various factors of importance in this crop are being investigated at Efford, Rosewarne and Ellbridge E.H.Stations.

A three year variety experiment 1961–63 at Efford comparing nine varieties, has shown that, for general purposes giving good yields of large berried fruit, Cambridge Favourite was the most regular variety each year. Heavier crops were produced by the exceptionally large berried variety Merton Princess, but it was too susceptible to fruit rots in wet seasons such as 1963 and cannot be generally recommended. Cambridge Prizewinner gave the best yields of early fruit of excellent quality and this variety, on sheltered early sites, might result in a higher profit per acre than the slightly later Cambridge Favourite, depending on the price structure each year. Cambridge Vigour and Cambridge Rival were also earlier than Cambridge Favourite and are useful varieties for sites infected with red core disease. Regina, a new continental variety, was very early every year but produced so light a crop that it cannot be recommended. Royal Sovereign was also included but gave light crops and must now be regarded as superseded by other varieties, some of which are as well flavoured.

Redgauntlet, an important variety because of resistance to red core disease, cropped heavily in 1961–62, but poorly in 1963 owing to fruit rotting and bruising. Further experiments are planned to test new varieties as they are introduced.

AUTOMATION OF THE HANDLING OF DATA FROM EXPERIMENTS

The use of electronic computers for the processing of data collected in the course of field experiments, has brought with it the problem of presenting the data in a form in which the computer can "read" it. This has usually entailed transferring

the written field record on to punched paper tape or punched cards. With paper tape input computers, there is little that can be done at present to avoid this transfer of data but with equipment now becoming available, it is possible to record the data at source directly on punched cards which can subsequently be handled by the computer. There is then a material saving of clerical labour and the possibility of eliminating copying errors without the laborious checking at present necessary. The Experimental Husbandry Farms and Horticulture Stations have been co-operating with their various statistical advisers in adapting such labour saving methods in data handling to their local circumstances. Early results are promising and suggest that, particularly in those trials where data must be accumulated over a long period before a realistic assessment of results can be made, the recording and storage of data on punched cards initiated at source is likely to be a worthwhile proposition.

Experimental Husbandry Farms and Horticulture Stations

Centre	*Acreage*	*Main Farming and Experimental Activities*
HUSBANDRY FARMS		
Boxworth E.H.F., Boxworth, Cambs.	858	Mixed farm on boulder clay. Friesian cattle for dairying and intensive beef. Cereal husbandry; haymaking techniques. Cross bred ewes and Large White pigs.
Bridget's E.H.F., Martyr Worthy, Winchester, Hants.	1,035	Large arable farm with leys on chalk. Ayrshire herd, Clun flock and Landrace pigs. Management and feeding of dairy stock, growing cereal crops, growth of leys and conservation.
Drayton E.H.F., Alcester Road, Stratford-on-Avon, Warwickshire.	469	Mixed farm on Lias clay. Beef cattle feeding: cross bred ewes. Utilization of grassland for beef and lamb production: grass conservation.
Gleadthorpe E.H.F., Welbeck Colliery Village, Mansfield, Notts.	493	Light sand arable farm. Rearing Friesian steers. Poultry. Production of arable crops: irrigation: maintenance of fertility: feeding and management of laying poultry.
Great House E.H.F., Helmshore, Rossendale, Lancs.	460	High lying Pennine farm in industrial area. Ayrshire cattle, Derbyshire Gritstone sheep, Large White pigs: poultry: management of dairy cattle: production, utilization and conservation of grass. Rearing and housing of laying hens.
High Mowthorpe E.H.F., Duggleby, Malton, Yorks.	1,080	Arable farm on high lying chalk. Cross bred beef cattle: cross bred ewes: Large White pigs. Production of cereal and root crops: rearing and feeding of cattle and sheep.
Kirton and Terrington E.H.Fs., Terrington St. Clement, King's Lynn, Norfolk.	311	Two silt farms run together. Large White and Essex pigs. Production of arable crops including cereals, potatoes, sugar beet, vegetables and soft fruit, also bulbs for forcing and tomatoes under glass. Pig breeding and management.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Liscombe E.H.F., Dulverton, Somerset	495	Upland grass farm adjoining Exmoor. North Devon cattle: Cross bred and Clun sheep. Breeding and rearing of cattle and lambs: production of grass and fodder crops.
Pwllpeiran E.H.F., Cwmystwyth, Aberystwyth, Cards.	3,100	Welsh mountain farm. Welsh sheep and Welsh Black cattle. Management of cattle and sheep: provision of winter fodder: shelter.
Rosemaund E.H.F., Preston Wynne, Hereford.	437	Mixed farm on heavy Red Sandstone soil. Hereford and cross bred cattle, cross bred sheep. Breeding and management of beef and beef × dairy cattle. Production of arable crops and hops.
Trawscoed E.H.F., Trawscoed, Aberystwyth, Cards.	808	Mixed farm on shale type soils with moor. Friesian cattle: Welsh and Half-bred sheep: Large White and Welsh pigs. Rearing and feeding dairy stock: growth and utilization of leys: breeding and management of sheep and pigs.

HORTICULTURE STATIONS

Cleppa Park E.H.S., Newport, Monmouthshire.	68	Production of fruit, vegetable and flower crops under local conditions, in the open, under Dutch lights and cloches, and in glasshouses.
Efford E.H.S., Lymington, Hants.	376	Nutrition and variety trials with top and soft fruit: vegetables including potatoes: tomatoes and other crops in heated and cool glasshouses: flower crops: irrigation.
Fairfield E.H.S., Greenhalgh, Kirkham, Preston, Lancs.	22	Glasshouse crops including tomatoes, lettuce: flowers: mushrooms: black-currants and raspberries.
Lee Valley E.H.S., Ware Road, Hoddesdon, Herts.	26	Glasshouse crops including tomatoes, cucumbers, lettuce, chrysanthemums: flowers in the open: mushrooms: mobile glasshouses.

Centre	*Acreage*	*Main Farming and Experimental Activities*
Luddington E.H.S., Stratford-on-Avon.	230	Apples, plums and soft fruit pest and disease control, nutrition and rootstocks: vegetables and flowers: mobile glasshouses: irrigation: weed control.
National Fruit Trials, Brogdale Farm, Faversham, Kent.	182	Testing and classification of all types of top and soft fruit.
Rosewarne E.H.S., Camborne, Cornwall.	109	Early bulb and vegetable crops including potatoes: mobile glasshouses: shelter.
Ellbridge E.H.S., (Sub-Station), Hatt, Saltash, Cornwall.	5	The study of early crops produced in the Tamar Valley.
Stockbridge House E.H.S., Cawood, Selby, Yorks.	161	Vegetable crops including rhubarb. Top and soft fruit: fixed and mobile structures: shelter: mushrooms: flowers.

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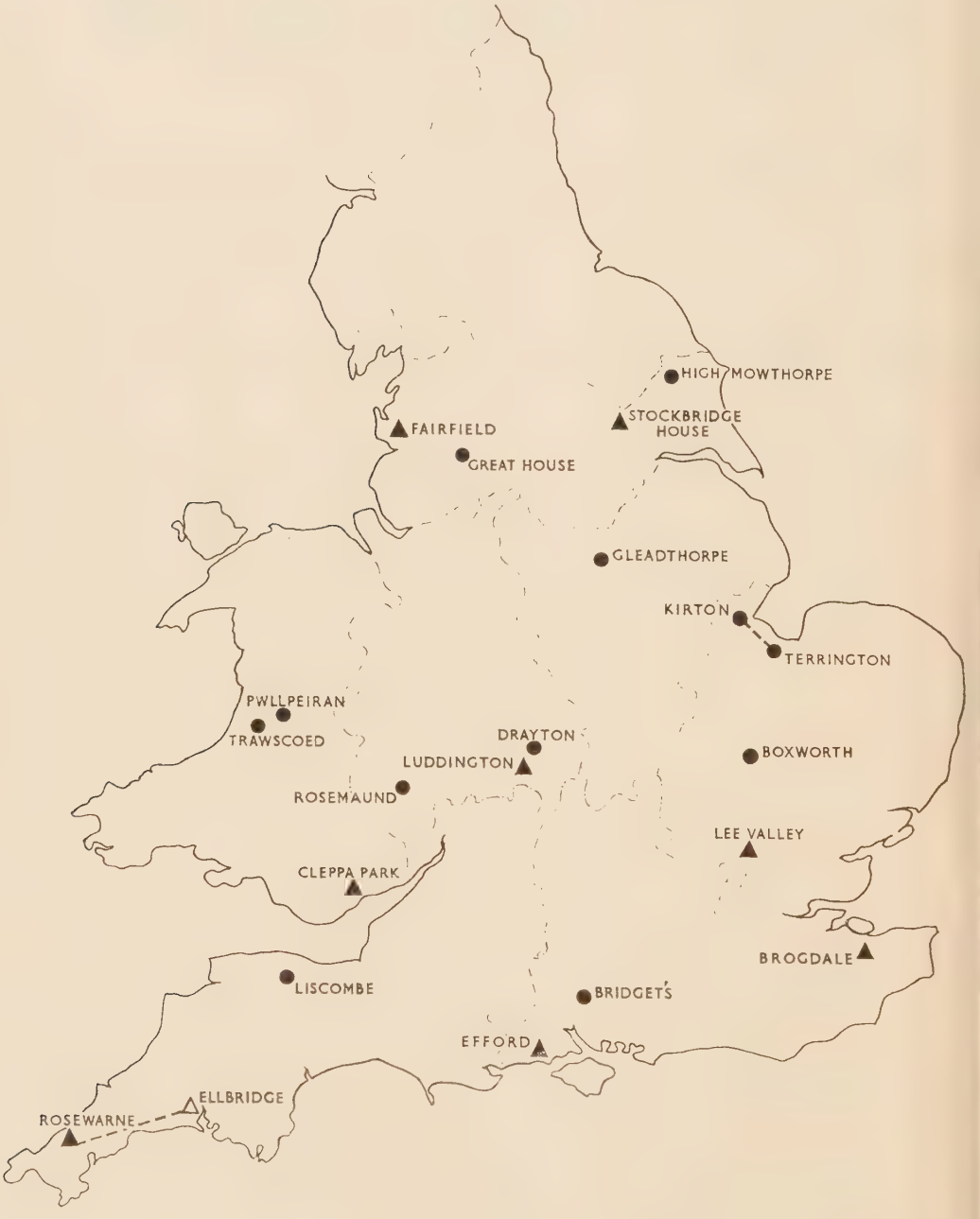

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